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NEW OR NOTEWORTHY SPECIES OF TREMELLALES FROM THE SOUTHERN APPALACHIANS

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In this paper, descriptions of three new species of jelly fungi are presented, in addition to a list of species collected by the writer in the southern portion of the Appalachian range during the summers of 1949 and 1950. Most of the collections were made in the vicinity of Highlands, North Carolina.

Platygloea arrhytidiae sp. nov. (figs. 1–10) Intra fructificationem *Arrhytidiae enatae* vegetans. Hyphae enodosae, conidiophororum fasciculos producentes; conidia e subgloboso ovoidea, 2.3–3.7 × 3–5.3 μ; probasidia 4.5–6.8 × 7.5–16.5 μ, basidia in cellulas 2 vel 4 divisa, 3.4–4.5 × 22–34 μ; basidio sporae ovatae vel breviter cylindraceae, 3–4.9 × 7.5.10.5 μ.

Growing within the fructifications of *Arrhytidia enata*. Hyphae without clamp connections; conidiophores produced in clusters; conidia acrogenous, subglobose to ovoid, 2.3–3.7 × 3–5.3 μ; probasidia produced mostly in small groups, occasionally singly, at the ends of hyphae, or sometimes arising further back along the hyphae, broadly obovate to clavate, often irregular in outline, measuring 4.5–6.8 × 7.5–16.5 μ; basidia arising terminally, or sometimes sub-terminally, on the probasidia, the latter remaining as empty cells at their bases, 2- or 4-celled, measuring 3.4–4.5 × 22–34 μ, sterigmata variable in length, basidiospores ovate or obovate to short-cylindric, somewhat appressed on one side, apiculate, 3–4.9 × 7.5–10.5 μ, germinating by repetition.

Collected near the Highlands Biological Laboratory, July and August, 1949–1950. A collection made on August 19, 1949, is designated as the type specimen.

The fungus produces no fructifications of its own, but appears to exist as a parasite within the fructifications of another jelly fungus, *Arrhytidia enata*. Its hyphae penetrate the gelatinous fructifications of the host and the sporulating structures appear on the surface of the host fructifications. In this respect, *P. arrhytidiae* resembles another species of *Platygloea* found by the writer (1946, 1947) within fructifications of *Dacrymyces*. Although this fungus was originally believed to be a form of *P. peniophorae*, it now seems likely that it also represents a new species. *P. arrhytidiae* differs from it in the size of its basidia and conidia and in the manner in which the conidia are produced. It differs also in having probasidia which persist as empty cells at the bases of the mature basidia. These persistent probasidia, which are rarely much-reduced or lacking, are thin-walled and variable in size and shape.

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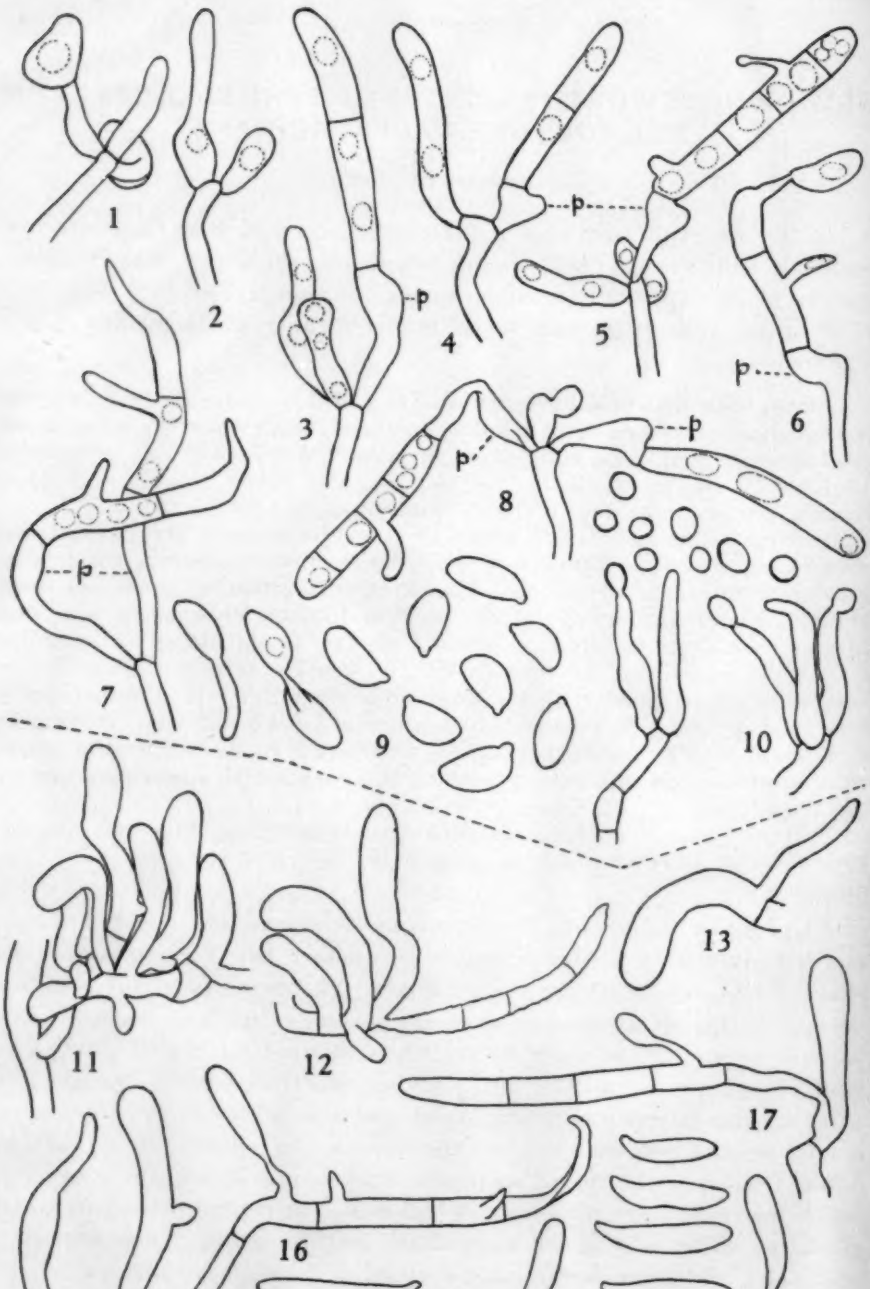
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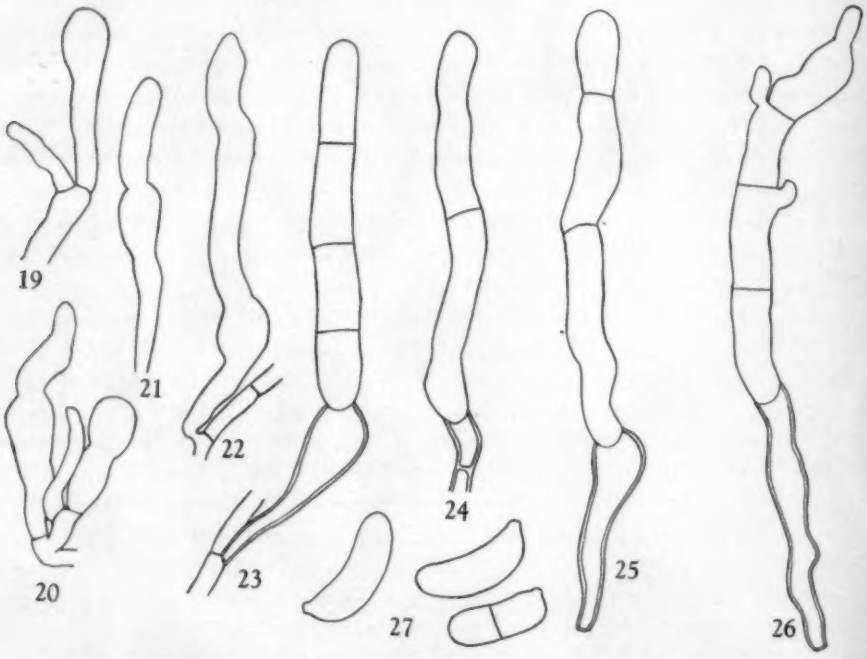
The presence of persistent probasidia in the genus *Platygloea* has not been generally acknowledged, and there was some question as to whether the new species should be placed in the genus. Recently, the writer examined a collection of the type species of the genus, *P. disciformis* (Fr.) Neuh. (*P. nigricans* Schröt.). The fungus (figs. 19–27) was collected in Sweden and identified by Dr. D. P. Rogers, who very kindly lent it to the writer for study. It was discovered that this fungus also has conspicuous probasidia, with only slightly thickened walls, persistent at the bases of the mature basidia. These probasidia vary from clavate or clavate-capitate to irregularly cylindrical in shape (figs. 23, 25, 26) and are rarely much reduced in size (fig. 24). Neuhoff (1924) has previously pointed out that there is a differentiation into "hypobasidium" and "epibasidium" in this species during basidial development and has demonstrated nuclear fusion in the "hypobasidium". However, he failed to emphasize the fact that the probasidium ("hypobasidium") persists as a conspicuous empty structure beneath the mature basidium ("epibasidium"). Although the probasidial wall is only slightly thickened, it is obviously thicker than the wall of the basidium proper.

The writer has also examined two other species of *Platygloea;* namely, *P. pustulata* Mart. & Cain and *P. fusco-atra* Jacks. & Mart., material of which was very kindly lent by Dr. G. W. Martin. Martin (1940) has already noted that "the empty hyphae below many of the basidia [of *P. pustulata*] are more or less swollen in such a way as to suggest the probasidia of *Jola.*" He also points out that new basidia proliferate through these empty structures. The present writer is able to confirm Martin's observations on *P. pustulata* and to state that these empty probasidial cells are almost always present at the bases of the basidia. They are thin-walled and tend to collapse early, and the basidia very readily become detached from them, so that they are not always conspicuous at this stage. However, even in earlier stages of development, there is a distinct demarcation between the long-clavate probasidium and the basidium which it produces at its apex. An examination of *P. fusco-atra* has also revealed the presence of empty thin-walled cells at the bases of the basidia. Here too they tend to collapse early, but the basidia are not so inclined to become detached from them as in *P. pustulata.*

The differentiation between basidium and probasidium has been observed in at least one other species; namely, *P. fimicola* Schröt. In his discussion

FIGS. 1–10. *Platygloea arrhytidiae.* FIGS. 1–8. Probasidia and basidia. Note 2- and 4-celled basidia and empty probasidia (p). FIG. 9. Basidiospores. FIG. 10. Conidiophores and conidia. FIGS. 11–18. *Helicogloea augustispora.* FIGS. 11, 12. Clusters of probasidia, some producing basidia. FIGS. 13–15. Germination of probasidia. FIGS. 16, 17. Mature basidia producing spores. FIG. 18. Basidiospores, some germinating by repetition. All figures, × 1200.

of this species, Martin (1944) suggested the possibility that persistent probasidia ("hypobasidia") may be present in other species of *Platygloea*. The present investigations indicate that these structures may have been overlooked in other species, although there appear to be some species in which they do not occur. The writer has not observed them in the species (described as a form of *P. peniophorae*) parasitizing *Dacrymyces*, nor in *Platygloea unispora* Olive (1944). However, these could hardly be considered typical members of the genus.



FIGS. 19–27. *Platygloea disciformis*. FIGS. 19–22. Probasidia, some of which are producing basidia. FIGS. 23–26. Basidia with empty probasidial cells at their bases. FIG. 27. Basidiospores. All figures, × 1170.

Since the type species has been found to have persistent probasidia, it is obviously necessary that the genus be redefined to include species which have persistent thin-walled probasidia. Since these structures are not of the well-modified type, such as one finds in *Cystobasidium* or *Septobasidium*, and since they may occasionally be much reduced or even absent in species commonly producing them, it would not seem advisable to segregate the species into two different genera, based on the presence or absence of the persistent probasidia. On the other hand, when more is known about the group, it will probably be found more convenient to recognize two series, or subgenera, which are distinguished from each other on this basis. A

redefinition of the genus, which would include both of the groups mentioned above, as well as the parasitic forms lacking distinct fructifications, is given as follows:

PLATYGLOEA Schröt. Fructifications waxy to gelatinous, lacking in some parasitic forms, effused and resupinate, sometimes pustulate; basidia clavate to cylindrical, 1- to 3-septate (nonseptate in one species); persistent pro-

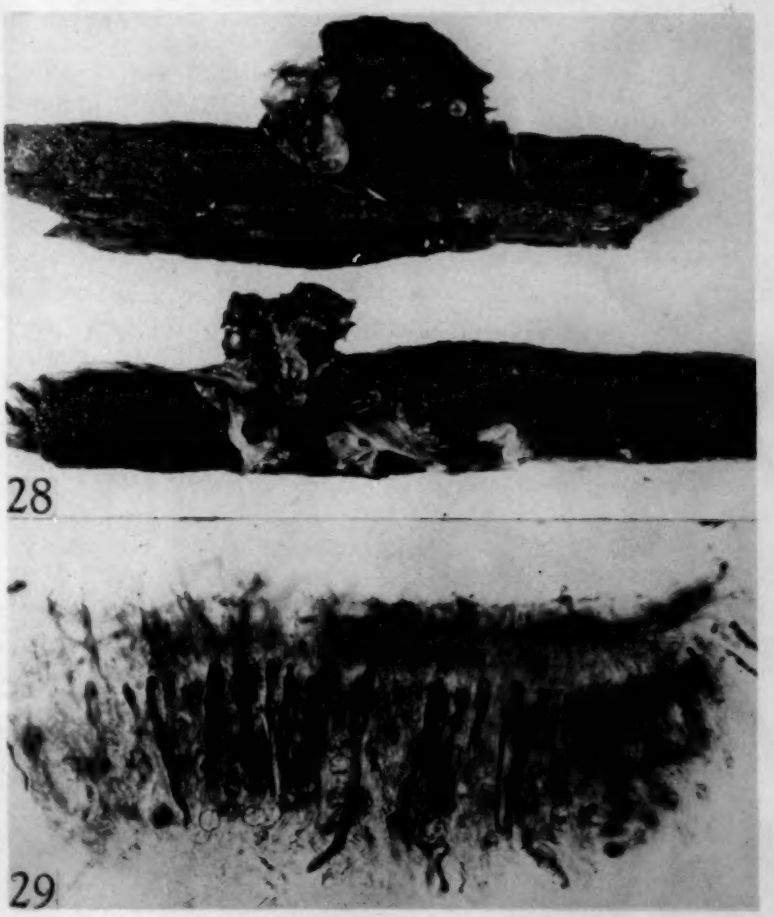
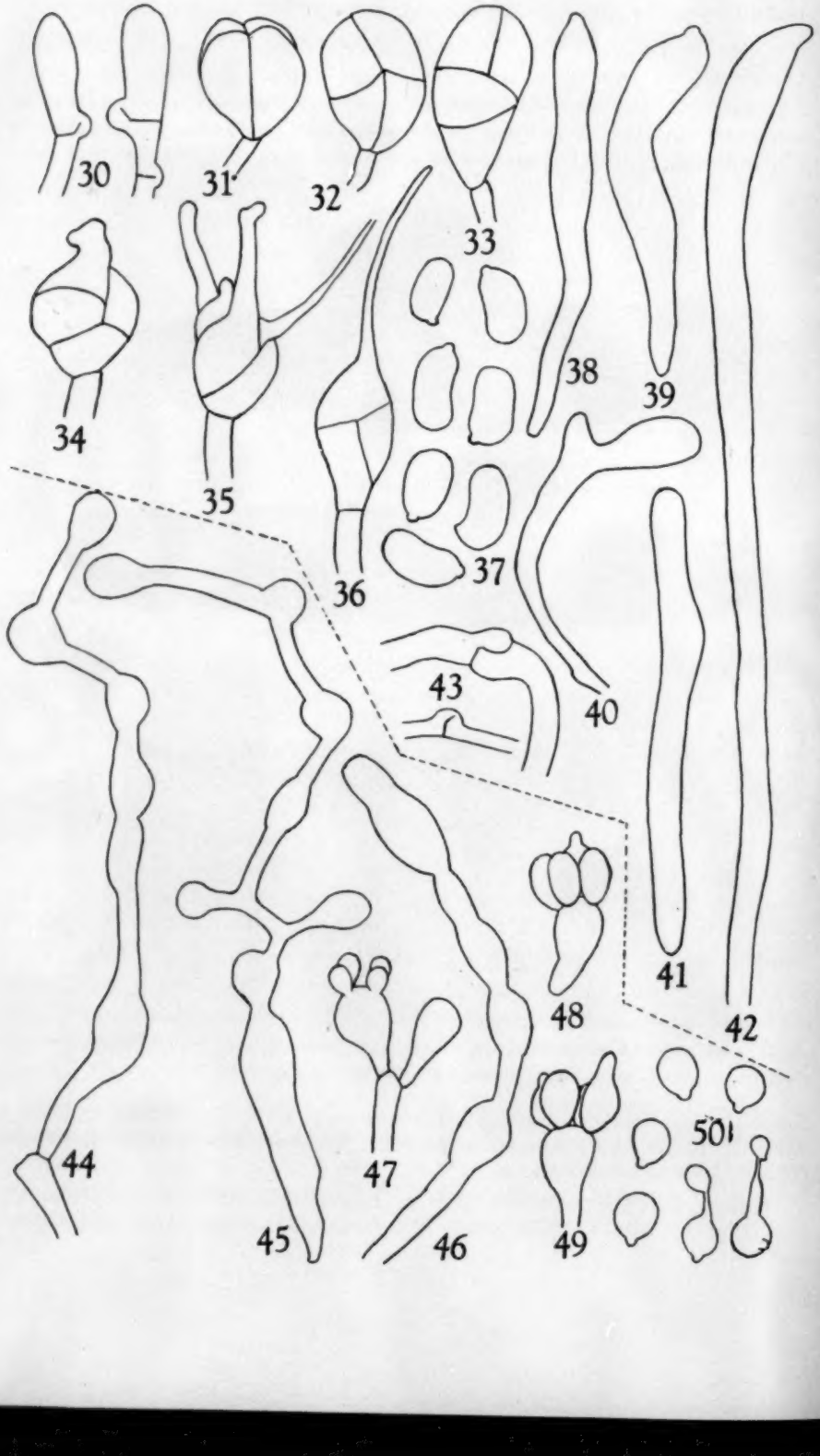


FIG. 28. Fructifications of *Seismosarca cartilaginea*. Natural size. FIG. 29. Vertical section through the hymenium, showing basidia and gloeocystidia. × 220.

basidia present or absent beneath the mature basidia, thin-walled and often variable in size and shape when present; basidiospores hyaline; hymenial conidia present or absent.

Helicogloea augustispora sp. nov. (figs. 11–18). Fructificatio pertenuis, mucoso-gelatinosa, sordide grisea. Hyphae enodosae, 2.8–7 μ diam., pro-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basidia clavata, frequenter constricta, in fasciculis orta, 4.8–6.4 × 14.4–32 μ; basidiorum pars sporifera 4-cellularis, 3.2–4 × 36–66 μ; basidiosporae typice auguste cylindracea vel fusiformia, 2.4–4.4 × 8.8–26.4 μ, per repetitionem germinantes.

Fructification a very thin mucous-gelatinous to soft waxy-gelatinous layer, with uneven, bumpy surface, sordid gray, drying to a thin, almost invisible film. Hyphae without clamp connections, 2.8–7 μ in diameter, probasidia clavate, frequently once or even twice constricted, produced in clusters, measuring 4.8–6.4 × 14.4–32 μ; basidia typically with stalk-like cell at the base, sporogenous portion 4-celled, measuring 3.2–4 × 36–66 μ; basidiospores narrowly cylindric or fusiform, 2.4–4.4 × 8.8–26.4 μ, germinating by repetition. Growing on a very rotten frondose stump in a rhododendron thicket, Highlands, North Carolina; August 29, 1950.

The new species differs from all previously described species of *Helicogloea* in its more narrow spores. Its nearest relative appears to be *H. longispora* Baker, which is reported on coniferous wood. The latter, however, has conspicuously larger probasidia and basidia. Furthermore, its basidiospores are considerably broader. Baker (1946) lists the spore measurements as 4.5–7.5 × 13–15 μ. The writer has examined a portion of the type, collected by Dr. D. P. Rogers, and finds that the spores measure 4.6–8.4 × 12.6 –28 μ.

The new species was found to be mixed in part with another species of *Helicogloea* which has ovoid spores and may be a form of *H. lagerheimi* Pat.

TREMELLA FOLIACEA (S. F. Gray) Pers. Several fructifications of this fungus were found at Highlands on a dead branch of white pine still attached to the tree. These fructifications, though smaller than is typical for the species, had the characteristic upright, plate-like lobes and brown color. The basidia measured 10.5–16.5 × 12.8–21 (–27) μ, and the basidiospores, 6.7–9.8 × 8.2–10.5 μ. Conidia are not produced on the hyphae, but are frequently budded out by the basidiospores and basidia. The fungus has been found in this country primarily on frondose wood. In Europe it is reported on both frondose and coniferous wood. Rea (1922) reports *T. foliacea* as occurring on coniferous wood and more rarely on frondose wood. Some of the European investigators have considered the form on coniferous wood to be of varietal significance. Bourdot and Galzin (1927) recognize the latter as *T. foliacea* var. *violascens* Alb. & Schw., while Neuhoff (1936) calls it *T. foliacea* f. *succina* (Pers.) Neuh. (= *T. succina* Pers.) and reduces the former varietal name to synonymy with it. If the varietal name is considered as valid, then, according to present rules of nomen-

FIGS. 30–43. *Seismosarca cartilaginea*. FIG. 30. Young probasidia. FIGS. 31–36. Mature basidia. FIG. 37. Basidiospores. FIGS. 38–42. Gloeocystidia. FIG. 43. Hyphae with clamp connections. All figures, × 1100. FIGS. 44–50. *Gloeotulasnella cystidiophora*. FIGS. 44–46. Gloeocystidia. FIGS. 47–49. Basidia. FIG. 50. Basidiospores, some of which show germination by repetition. All figures, × 1200.

clature, the correct name is *T. foliacea* var. *violascens* (Alb. & Schw.) ex Fries. However, since there appear to be no very significant differences between the form on coniferous wood and the one on frondose wood, the varietal name is not recognized here.

Seismosarca cartilaginea sp. nov. (figs. 28–43). Fructificatio cartilagineo-gelatinosa, fragilis, irregulariter plicata, alutacea in cinnamomeo-brunneam vergens, 1×1.5 cm. vel ab anastomosi 3×5 cm., ad 1.5 cm. alta. Hyphae nodoso-septatae, hymenio 120–265 μ crassit.; gloeocystidia lutea vel brunnea, elongato-cylindracea vel anguste clavata, $4.2–11.2 \times 38–196$ μ; basidia e subgloboso pyriformia vel obovata, plerumque in 4 segmentis divisa, $11–14.3 \times 13.2–22$ μ; basidiosporae oblongae vel subreniformes, $4.4–6.6 \times 8.8–13.2$ μ, per repetitionem germinantes.

Fructifications cartilaginous-gelatinous, brittle, irregularly folded, tan to cinnamon brown, 1×1.5 cm. up to 3×5 cm. by anastomosis, reaching 1.5 cm. in height, becoming dark brown and only partly shrunken on drying. Hymenium 120–265 μ thick, containing small calcareous granules; hyphae with clamp connections; gloeocystidia very abundant, contents yellow to brownish, finely granular to somewhat viscous in appearance, long cylindrical to slender-clavate, $4.2–11.2 \times 38–196$ μ, basidia subglobose to pyriform or obovate, mostly 4-celled, $11–14.3 \times 13.2–22$ μ; basidiospores oblong to somewhat reniform, apiculate, $4.4–6.6 \times 8.8–13.2$ μ, germinating by repetition.

Growing on frondose log, probably chestnut, near Jocassee, South Carolina; July 5, 1950.

The fungus was collected not far from the place where Michaux is believed to have discovered the rare flowering plant, *Shortia*. The latter may still be found growing in the area. Botanically, this northwest corner of South Carolina is one of the most interesting in all the southern Appalachians.

The new species of *Seismosarca* is easily distinguishable from *S. alba* Lloyd in color, form and texture, and in the production of yellow or brownish gloeocystidia. It differs in form and texture from *S. hydrophora* Cke., which has effused or erumpent, mucous-gelatinous fructifications that dry to a vernicose film. It also differs in form and texture, as well as in its microdimensions, from *S. tomentosa* Olive (1947). The fructifications of the new species are unique in being firmly cartilaginous-gelatinous in texture, and in having a tendency to fragment rather readily when handled. The three species mentioned above are the only ones which have thus far been placed in the genus, which is distinguished from related genera by the presence of gloeocystidia.

The hymenium contains, in addition to gloeocystidia and basidia, numerous indistinct, branched hyphae which are hardly sufficiently modified to be considered paraphyses. The gloeocystidia are quite variable in size and shape and sometimes show a tendency toward forking (fig. 40). Often

there is present at the base of a gloeocystidium a hypha with yellow contents which passes deep into the interior of the fructification. The gloeocystidia are very abundant in the surface layer of the fructification, both in the hymenium and in sterile areas where basidia are lacking. The basidia are found at various levels in the hymenium, but are more abundant in the central and lower portions. Basidia with oblique and horizontal septa are probably more common than those with all the septa vertical.

GLOEOTULASNELLA CYSTIDIOPHORA v. Höhn. & Litsch. (figs. 44–50). As Rogers (1933) points out, this species of *Gloeotulasnella* is distinguishable from all other known species in its production of long and *irregular* yellow gloeocystidia. In this collection most of the gloeocystidia are long and moniliform, as the figures show. The fructification is thin, grayish, and very soft gelatinous. The fungus agrees well with the description given in Rogers's monograph. The basidiospores, which are globose to broadly obovate, measure 4–5.6 × 5.3–6.8 μ.

Martin (1944) has reported the occurrence of *G. cystidiophora* in Massachusetts, Iowa, and Ontario. Previously, it was known only from Finland and Great Britain. It was collected once on decorticate frondose wood at Highlands, North Carolina, August 9, 1949.

A number of other jelly fungi were collected by the writer in the southern Appalachians, mostly in the vicinity of Highlands, North Carolina, during the summers of 1949 and 1950. These are listed as follows: *Arrhytidia enata* (Berk. & Curt.) Coker, *Calocera cornea* (Fr.) Link, *Dacrymyces deliquescens* Duby, *D. ellisii* Coker, *D. minor* Peck, *D. palmatus* (Schw.) Bres., *D. punctiformis* Neuh., *Dacryomitra nuda* (Berk. & Br.) Pat., *Dacryopinax spathularia* (Schw.) Mart., *Exidia glandulosa* [Bull.] Fr., *Gloeotulasnella pinicola* (Bres.) Rogers, *Guepiniopsis torta* (Fr.) Pat., *Sebacina hevelloides* (Schw.) Burt, *S. opalea* Bourd. & Galz., *S. podlachica* Bres., *Seismosarca hydrophora* Cke., *Tremella tubercularia* Berk., *T. mycophaga* var. *obscura* Olive (parasitizing *Dacryomitra nuda*), *T. reticulata* (Berk.) Farl., *T. subanomala* Coker, *Tremellodon gelatinosus* (Pers.) Fr., *Tremellodendron candidum* (Schw.) Atk., *Tremellodendron* sp.

The writer is very grateful to Dr. D. P. Rogers for his preparation of the Latin descriptions, for the loan of herbarium material, and for valuable assistance with taxonomic problems. Most of the investigations were performed at the Highlands Biological Laboratory, Highlands, North Carolina.

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OBSERVATIONS OF CANE (ARUNDINARIA) FLOWERS, SEED, AND SEEDLINGS IN THE NORTH CAROLINA COASTAL PLAIN

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Cane, *Arundinaria*, is a true grass, with a perennial woody stem that sets it apart from all other grasses in this country. It is a member of the bamboo tribe. Most botanical manuals list two species of cane or reed: *Arundinaria gigantea* (Walt) Chap., large cane or southern cane; and *Arundinaria tecta* (Walt) Muhl., small cane or switch cane.

This tall woody grass, which forms thickets or brakes is widely distributed in the Southern and Southeastern states. Early settlers had a high opinion of the canebrakes as natural pastures, and the experience of grazers ever since has confirmed the forage values of cane. Recent tests in North Carolina show that cane is possibly the highest yielding native range in the U. S.[1] Thus, where canebrakes are extensive, their use for grazing makes them an important local resource. This is particularly true in the North Carolina Coastal Plain, where the survey (Biswell and Foster, 1942) of forest grazing in 1940–41 showed that "The reed forage type is the most important for grazing and can be used nearly all the year." Cane provided 46 percent of the forest grazing in the forage types on the North Carolina Coastal Plain farms surveyed. This is in spite of the destruction of large canebrakes by cultivation, fire, and overgrazing.

Most everywhere throughout its range the area of canbrakes is decreasing because of fire, uncontrolled grazing, and the clearing of land for cultivation. Once it is killed out, cane comes back so slowly that it will not restock naturally for several generations. The long delay or failure of reestablishment is due in large part to its habits of reproduction. This paper endeavors to fill in some of the blank spots in our knowledge of the life cycle of this arborescent grass with information obtained in connection with forest-grazing investigations in the Coastal Plain of North Carolina.

General characteristics. Most botanists recognize two species of cane. But the points of difference used in descriptive keys, namely, stem origin, height, and position of panicles (Hitchcock, 1935), do not facilitate a distinction in eastern North Carolina. "Panicles on leafy branches," descriptive of *A. gigantea*, and "panicles on leafless shoots from creeping rhizomes," giving the comparable character for *A. tecta*, can be applied to

[1] Southeastern Forest Experiment Station, Research News, No. 5, May 1949.

growth forms which commonly occur on the same rootstock in eastern North Carolina. From our observations, however, flowering branches on established stems are rarely leafy, and the flowering of new leafless shoots usually occurs at a later date than that on established stems (fig. 1). In undisturbed colonies, panicles usually occur on the branches of established stems, as attributed to *A. gigantea*. However, if the old stems are burned or cut off, panicles are born on leafless new shoots from the rhizomes, as attributed to *A. tecta*. Other descriptive characteristics, such as height, overlap between

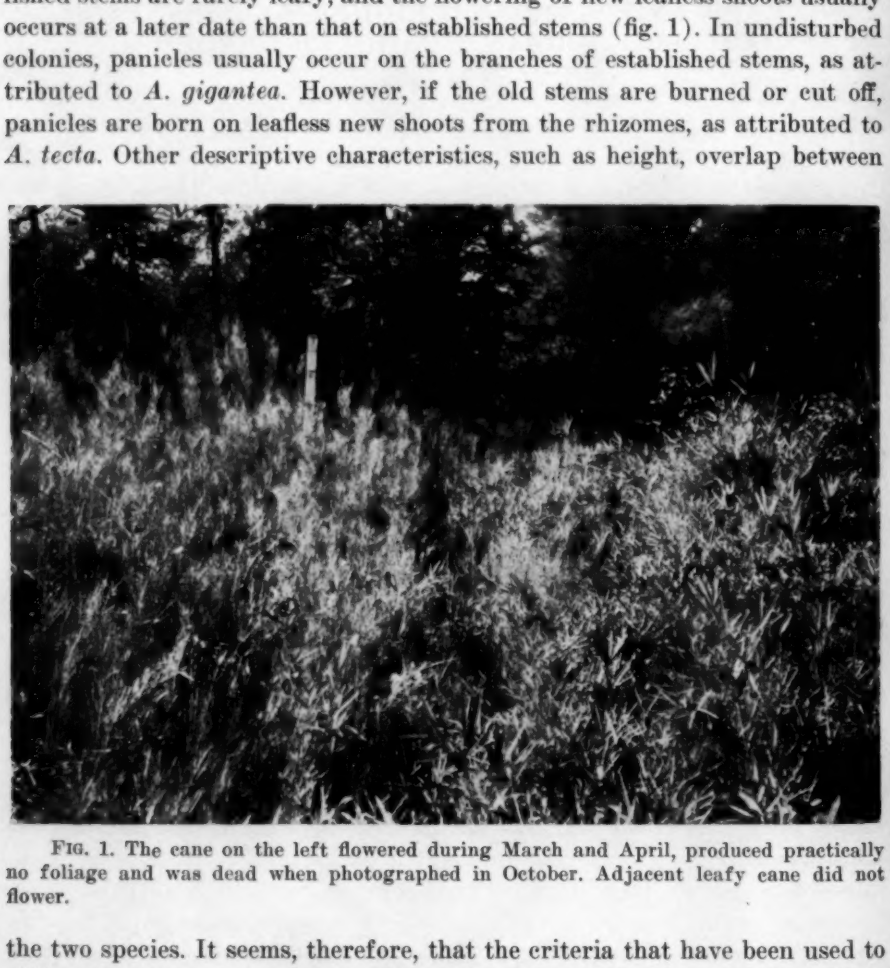

FIG. 1. The cane on the left flowered during March and April, produced practically no foliage and was dead when photographed in October. Adjacent leafy cane did not flower.

the two species. It seems, therefore, that the criteria that have been used to differentiate *A. gigantea* from *A tecta* are of questionable validity. Gilley recognizes two types of North American *Arundinaria*, the "*atlantic-type*" and the "*mississippi-type*," without attempting to differentiate species (Gilley, 1943). Spikelet and leaf-sheath characteristics of cane observed in eastern North Carolina correspond to the "*atlantic-type*." Because of the confusion in nomenclature the plant is referred to in this article as cane, the common name recognized for *Arundinaria* in "Standardized Plant Names" (Kelsey and Dayton, 1942).

In contrast to other grasses mature cane plants vary widely in size,

some having a diameter of less than an eighth of an inch and a height of only a few inches; others are an inch or more in diameter and twenty or thirty feet tall. The bulk of the cane observed in North Carolina ranges from three to ten feet in height. Sometimes the smaller sizes form pure stands, and elsewhere tall canes dominate an area with only a few small plants among them. The culms (aerial stems), first appearing as very succulent tender shoots, arise rapidly in mid-summer from rhizomes (underground stems). The new culms develop seven to twelve large leaf blades the first year; simple lateral branches, each carrying five to twelve leaves, appear the second year; additional branches, carrying five or six leaves apiece, develop each growing season during the remainder of the life of the culm. Stems live several years. In older brakes a number of canes die each year and are replaced by a comparable number of new shoots. Where aerial portions have been killed by fire, cut off or broken, new culms arise from the underground parts of the old culm.

Flowering habits. At Tidewater Experiment Station, near Plymouth, North Carolina, range pastures containing cane stands of different heights, in the open and under trees, were established in 1948 for grazing studies. The cane stands are carefully inventoried annually. Patches of cane which flowered and died comprised only a small fraction of one percent of the range areas in 1948, but approached one percent in 1949. Flowering patches covered as much as three percent of individual acres the first season, and as much as six percent the second year. In addition, single stems flowered here and there, particularly on new growth from cane stubble where paths had been cut through old canes for fence lines.

The flowering time, so far as we know, is entirely unpredictable. Stunted specimens a few inches high seem as apt to bloom as those ten or fifteen feet high. A plant scheduled to flower apparently goes ahead with the process regardless of environmental conditions. The following case is an example. A rhizome section clinging to soil around the roots of a royal fern was transplanted with the fern from a wooded ditch bank in late summer while the cane was in full leaf. Early the following spring the undisturbed cane in the vicinity of the ditch bank as well as the section removed with the fern, produced flowering panicles, the former from aerial stems and from basal shoots, and the latter from new basal shoots (aerial stems having been discarded in transplanting).

Seeding Habits. Historic records of canebrakes fail to mention seedling establishment. But Dunbar (1930) gives a description (1798) of seeding habits: "It produces a very abundant crop of Grain, and that only once, for it immediately after perishes root and branch, it is not known how many years the reed required to arrive at this state of maturity . . . for I who have lived . . . (Twenty-five years) . . . in this country and have frequently

traversed many extensive tracts of it, have never in any one year, seen 1/500 part of the canes in seed. . . ."

West (1934) refers to the following information from an autobiographical sketch written by the Hon. Francis D. Bolton of New Harmony, Indiana: "Fox Island was full of game from my earliest recollections up to the year 1850, when the cane, with which it was covered, went to seed and then all died. The seed grew in clusters and resembled oats, and all the animals and fowls got rolling fat from eating this seed. The squirrels were so fat that their kidneys were covered. This food imparted a delicious flavor to the flesh and we feasted that summer and fall. But this was the end of the cane on Fox Island, as it all died the following winter and was either carried off by high water or rotted on the ground."

At Tidewater Experiment Station deterioration of the aerial plants began with the shattering of flowering branches in April, followed by the upper stem in May. Apparent life of the old plant ended with the shedding of the last flowering radical branches in late summer. Roots degenerated simultaneously with the aerial portions of the old stems. The larger, healthy root stocks, with their accompanying radical flowering shoots, were the last parts of the plant to deteriorate.

Present-day fruiting habits seem to be as irregular as those described 160 years ago. Thus far, limited observations in North Carolina indicate that from the few plants that flower perhaps one out of 10,000 florets produces viable seed. In cane stands at the Tidewater Station fertile florets tend to become increasingly more abundant as the area and density of the flowering colony increases, and a large patch is apt to yield a much higher percentage of viable seed than scattered lots of a few stems. Heavy yielding panicles may produce as many as four or five rye-like kernels per spikelet. Fruit reached a stage analogous to the "early dough stage" of cereal grains April 8, 1949. The late dough stage was observed April 28, 1949 after which date the seed shattered readily (fig. 2). This is the only means of seed dispersal observed. Seed collected the second week in May were viable. Germination may occur within a few days after the seed reaches the ground. New seedlings appeared in June from seed dispersed in May.

A high percentage of the grain observed on plots at the Tidewater Station has been destroyed before leaving the plant. An unidentified larva bores into the seed near the base and devours the starchy endosperm. The blackened empty grain falls to the ground, and the larva, if not full size, searches for another healthy kernel. Generally, a young larva one millimeter or so in length occupies a young grain of comparable size, whereas those three or four millimeters in length occupy larger grains. Kernels that survive past the dough stage are not molested. General infestation has been observed during the 1948 and 1949 fruiting seasons in North Carolina.

First efforts to propagate and identify the adult stage of the insect have not been successful. Larvae were isolated in an aerated container and fed an ample supply of cane fruit. After they had apparently completed their growth the larvae died.

FIG. 2. Seed panicles on branches of an old stem. Most florets had matured and shattered when photographed in May. Note absence of foliage.

Destruction of the seed may be avoided by dusting the panicles during the flowering and fruiting stage with 5 percent DDT. Several pounds of grain were obtained from a plot receiving this treatment.

Recent observations of natural seedlings. The following descriptions

refer to the growth habits of natural seedlings growing in cane areas at the Tidewater Station with and without a canopy of trees.

Usually, first-year seedlings produce a spray of three to six leaves that appear in May and June on a single stem. The initial stem is the size of a common hatpin. The leaves persist into the winter and occasionally two or three upper leaves survive into the next growing season. After the leaves have fallen, the leafless stem may persist one or more years. The old seed coat remains intact at the base of the stem for a year or more after germination.

By the end of July of the second year most seedlings have produced another spray of leaves on a basal upright shoot, which essentially is a leafy branch rising from the lowermost bud at the base of the initial stem. Except for the barren stem carried over from the first year, this form remains little changed from the first-year plant. However, a second shoot frequently is born by a bud at the base of the old stem and two leafy branches may develop; each branch or stem bears four to six leaves comparable in size to those of the first year.

During the third year the cane seedling may closely resemble the younger plants already described, except for additional residual dead leaf branches or stems which have persisted one or two years. Development of perennial culms also has been a common feature of growth during the third season. These produce single branches which add a few inches of sustained height to the plant.

Ordinarily, the limited shallow root system continues to develop very slowly. Most roots were found in the raw humus layer, which may be waterlogged for extended periods during the year. Seedling development is delayed by the slow transition from a meager fibrous root to the appearance of rhizomes. The first rhizome on a seedling was observed in August 1949 on a plant grown from seed in 1947. This initial root stock elongated for a distance of five inches horizontally through a layer of mulch, developed three nodes each having numerous roots extending into mineral soil, and then turned directly upward into an aerial leafy stem, (fig. 3). In late fall, 1949, this aerial shoot was about 10 cm. in height and carried five leaves 5 or 6 cm. in length. Leaf and height growth was continuing.

It has been noted that established cane stands are sustained by radical shoots supported by a network of rootstocks. These aerial shoots elongate as much as 1½ inches in a 24-hour period and 12 to 15 feet during the summer. Buds which alternate on the top and bottom of rootstocks, and sometimes along the sides, may develop into either a culm or a rhizome branch. Usually, three to five roots accompany the bud at each node.

These observations indicate that cane seedlings must await development of rootstocks in order to attain substantial height growth and the subse-

quent adult stage. During the second and into the third year, seedlings growing in their natural surroundings added branches and new basal shoots, but the form and extent of their initial root system remained basically unchanged.

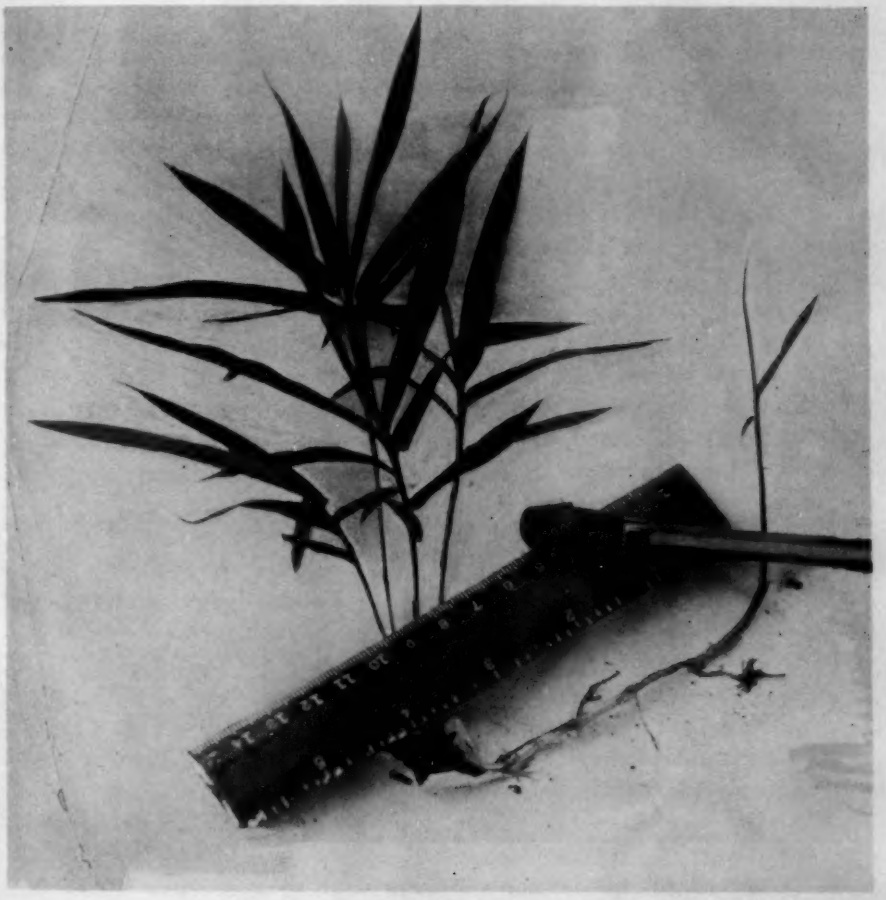

FIG. 3. Natural seedling in midsummer of the third season after germination. This vigorous plant has produced a lateral rhizome which is developing into a new stem.

Observations of seedlings under cultivation. In order to expedite the growth of seedlings and the history of their development, several hundred seeds were started in flats and transplanted into prepared plots. Seeds which appeared healthy were selected and sown on the surface of a mixture of woods peat, sand and garden soil, and covered with a mulch of partly decayed organic debris. The seeds were collected and planted while in the late dough stage. Care was taken to prevent seed from drying before and

after planting. The well-drained planting medium was kept moist with frequent applications of city water (pH 7.4 to pH 7.5). From the 400 seed planted, 124 seedlings reached the second-leaf stage and were transplanted into two prepared plots, one at Frying Pan Range near Columbia, N. C. and one at Tidewater Station. Plots were selected in partial shade, in relatively well-drained sites protected from live-stock. One-half of each plot was treated with 2–12–12 fertilizer at the rate of 600 pounds per acre. Provision was made for irrigating; the location of each transplant was marked on the ground and its location charted. The plots are kept free of weeds.

It was expected that artificially propagated seedlings would develop much more rapidly than those growing naturally, and this has proved true. In contrast to the limited lateral rooting habit of naturally sprouted seedlings growing on poorly drained sites, seedlings growing in aerated, moist soil develop a primary root to a depth equaling the height of the vigorous leafy stem. Current first-year seedlings sent up a second basal branch at the age of three months. Heretofore, a second branch has not been observed on natural seedlings until the second or third year. By late fall of their first growing season these hand-planted seedlings had developed as many as four basal leafy branches, each supporting five to eight leaf blades 25 mm. to 45 mm. in length. However, the root system remained simple, and the over-all height growth was limited from 8 cm. to 13 cm.

SUMMARY

1. Specimens of *Arundinaria* observed in eastern North Carolina do not fit the descriptions for either *A. tecta* or *A. gigantea*, the two species generally treated in descriptive keys.

2. Cane seeds collected the second week in May were viable and new seedlings appeared in June from seed dispersed in May.

3. Large quantities of seed were produced but most of them were destroyed by an insect larva before they were dispersed.

4. Destruction of seed by insect larvae was controlled by dusting with 5 per cent DDT.

5. Natural seedlings develop very slowly; those observed were less than a foot tall by the end of the third growing season.

6. Cultivated seedlings develop more rapidly; at about twice the rate for natural seedlings.

SOUTHEASTERN FOREST EXPERIMENT STATION
ASHEVILLE, NORTH CAROLINA

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NOTES CONCERNING ENTOMOGENOUS FUNGI

E. B. MAINS

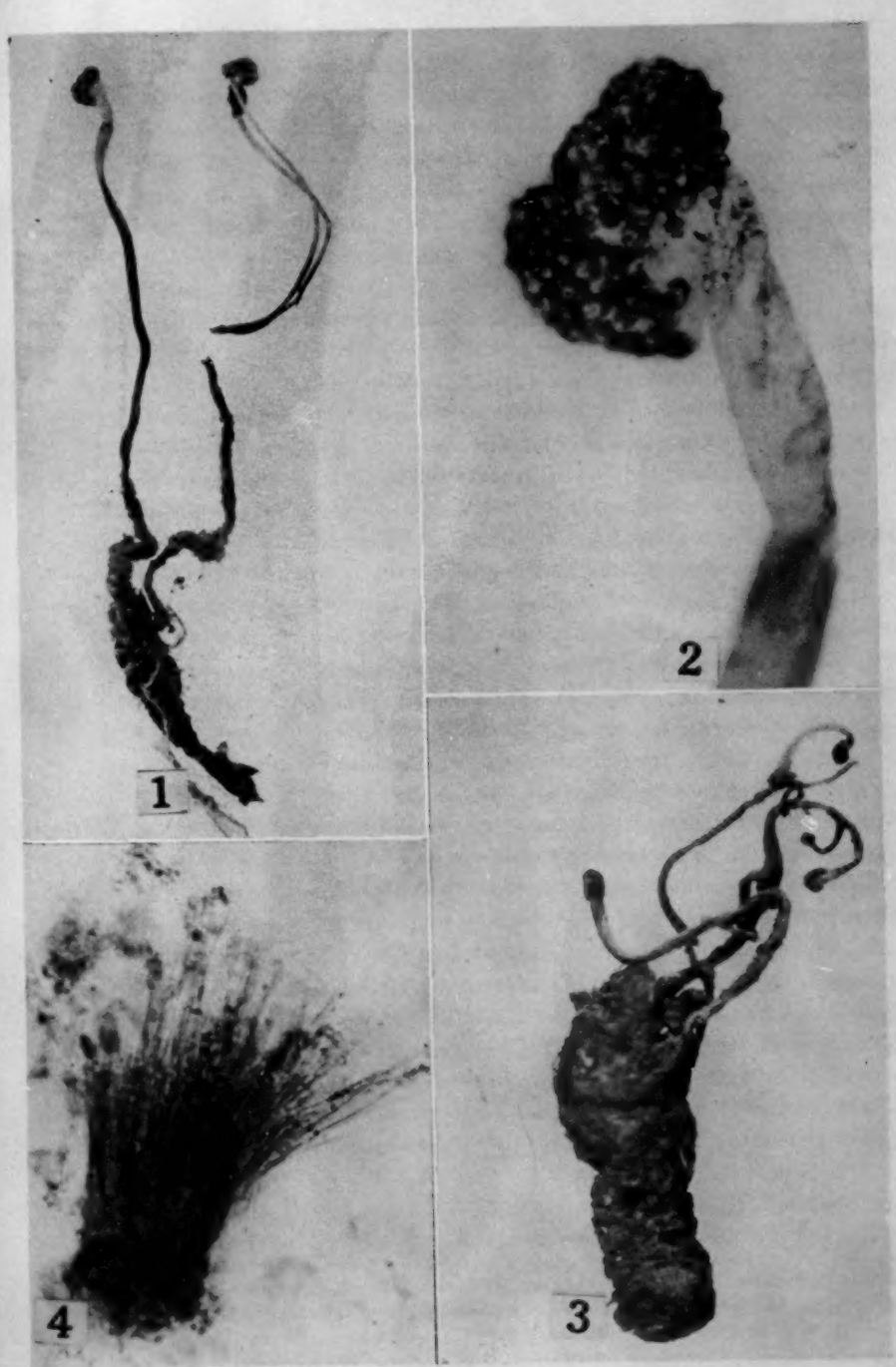
CORDYCEPS ENTOMORRHIZA (FR.) LINK. In the summer of 1949 a specimen of a *Cordyceps* collected by Mrs. Wm. B. Cooke in Mt. Rainier National Park, Washington was received from Dr. A. H. Smith who was engaged in a study of the mycological flora of the park. This has been determined as *Cordyceps entomorrhiza* (figs. 1 & 2). It is an interesting collection since, as far as the writer is aware, it is the first collection of *C. entomorrhiza* for North America. Although *C. entomorrhiza* has been reported a number of times for North America the name has been misapplied to *Cordyceps gracilis*. Also a conidial stage has been found on the specimen which differs from the conidial stages which have been previously suggested. The following description has been prepared from the Mt. Rainier specimen.

Clavae two, 3.5–4.0 cm. long, slaty gray when dried, the heads irregularly oblate-spheroid, 2×3 mm., light vinaceous drab when fresh, verrucose from the projecting upper portions of the perithecia (fig. 2), the stipes slender, 0.5–0.8 mm. thick, pallid brownish in the upper part, deep slaty brown below when fresh, pruinose above, glabrous below; perithecia conoid, 600–650 ×230–270 μ, completely embedded at right angles to the surface of the head with the flesh shrunken between the apices; asci cylindric, 275–300 × 4 μ, the wall thin, thickened at the apices 2.5–3 μ; ascospores filiform multiseptate, breaking into unicellular fragments, $6–8 \times 1.5$ μ; phialides produced in a compact palisade layer on the upper pruinose portion of the stipes, subcylindric to clavate, $12–16 \times 2–2.5$ μ, hyaline, arising laterally from the outer hyphae of the clavae or on short lateral cells, sterigmata lacking or very short; conidia narrowly ellipsoid to fusoid, $5–8.5 \times 2–3$ μ, narrowing but rounded at the ends.

On a coleopterous larva, in alder flat, S. W. Entrance, Mt. Rainier National Park, Washington, 7-10-48, Mrs. Wm. B. Cooke, A.H.S. 28906.

Dickson (1785) described *Sphaeria "entomorhiza"* on the larvae of insects from England. He states that the clavae are stipitate, capitate and fuscus. His illustration shows a bifurcate clava arising from what appears to be the larva of a beetle. The two heads are spherical and definitely verrucose. Fries (1823) published the species as *Sphaeria entomorrhiza* in his Systema

FIGS. 1 & 2. *Cordyceps entomorrhiza* from Mt. Rainier National Park. FIG. 1. Two clavae, the right split longitudinally in the upper portion. ×1.8. FIG. 2. Head of a clava showing projecting perithecia and upper pruinose portion of stipe which bears conidia. ×14. FIGS. 3 & 4. *Poiycephalomyces ramosa* (*Cordyceps entomorrhiza* forma *spermatophora* Rab. Fungi Eur. 1218). FIG. 3. Lepidopterous larva with branched synnemata arising from the posterior end. ×3. FIG. 4. Portion of the hymenium of the head of a synnema showing loosely arranged subulate phialides. ×750.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Mycologicum. His description agrees closely with that of Dickson. He, however, reports the species from Carolina and states "Variat in America colore dilutiore."[1]

Greville (1824) described *Xylaria gracilis* as follows, "stipes elongated, cylindrical, equal, somewhat flexuous; receptacle smooth, roundish-ovate, brown; spherules oblong, pale." His illustrations show a smooth head with completely embedded perithecia. Short rhizomorphs are shown at the bases of the stipes. An association with an insect is not noted.

Berkeley (1860) reported *Cordyceps entomorrhiza* from the British Isles on pupae and larvae of moths. His description and illustrations agree very closely with those of Greville for *Xylaria gracilis*. The head of the clava is smooth not verrucose as in *C. entomorrhiza*.

Probably mislead by collections received from Britain from C. E. Broome, the Tulasnes (1865) under the name *Torrubia entomorrhiza* described and illustrated[2] *Cordyceps gracilis*. They recognized the similarity to *Xylaria gracilis* Grev. They (1859) also described a species, *Torrubia cinerea* having a stipe black or blackish fuscus below and glauco-cinereous and delicately pulverulent above and having a head at first whitish cinereous becoming pale fulvo-violaceous. The host was a coleopterous larva of the genus Carabus. As has been pointed out by Lloyd (1913) and Petch (1933) their *Torrubia entomorrhiza* is apparently *Cordyceps gracilis* and *Torrubia cinera* is *Cordyceps entomorrhiza*. The latter has been frequently reported as *Cordyceps cinerea* on the continent of Europe.

Quélet (1898) described *Cordyceps carabi* occurring on larvae of a beetle. The color of the stipe is given as violet and the head as lilac. According to the illustration the head is verrucose. Petch (1933) considers this to be a synonymn of *C. entomorrhiza*.

Cordyceps gracilis varies in color from chestnut brown through cinnamon buff to orange buff. The head is punctate with darker colored ostioles which project only slightly and the head is relatively smooth even when dried. It is usually reported on larvae of lepidoptera. The few reports on coleoptera may be a related species. Dickson described *Cordyceps entomorrhiza* as fuscus. Accepting *C. cinerea* and *C. carabi* as synonymns the color of the species varies through brownish violaceous to slaty grey, and violaceous. The upper portions of the perithecia form hemispherical projections making the surface of the head distinctly verrucose. The species

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[1] The citation of Carolina is probably based on the report by Schweinitz (1822) whose description indicates *Cordyceps gracilis*.

[2] The Tulasnes' figure 12 of plate 1 is from the larva of a beetle and shows a clava with a verrucose head. This probably is *Cordyceps entomorrhiza*. The description and figures 13, 14 and 15 showing clavae with smooth heads on lepidopterous larvae apply to *Cordyceps gracilis*.

infects coleopterous larvae. The collection from Mt. Rainier thus evidently falls within the specific limitations of *C. entomorrhiza*.

There is considerable confusion concerning the conidial stage of *C. entomorrhiza*. Schroeder (1908) gave *Isaria eleutheratorum* Nees as the conidial stage of *Cordyceps cinerea* for which he used the name *Torrubia eleutheratorum*. He, however, did not state that the ascogenous and conidial stages were found associated. Petch (1932) transferred *I. eleutheratorum* to *Hirsutella* and stated that it probably was the conidial stage of *Cordyceps entomorrhiza* but that the relationship had not been established.

Later Petch (1933) decided that the conidial stage was *Stilbella setiformis* (Vahl) Petch since he had found it associated with the ascogenous stage of *C. entomorrhiza* in collections made by Auerswald and Delitsch near Leipzig (Rabenhorst Fungi Europaei Nos. 1010 and 1218). Kobayasi (1937) found immature perithecial heads resembling those of *Cordyceps entomorrhiza* associated with *Tilachlidiopsis nigra*. Petch (1939) concluded that *Stilbella setiformis* and *Tilachlidiopsis nigra* were parasites of entomogenous fungi and not parasites of insects. He again states that *Hirsutella eleutheratorum* is probably the conidial stage of *Cordyceps entomorrhiza* although he does not report an association of the two stages.

The conidial stage which occurs on the perithecial clavae of the Mt. Rainier specimen does not have phialides with long sterigmata and conidia with thick mucus which are characteristic of *Hirsutella* and is therefore not *H. eleutheratorum*. The phialides and conidia are similar to those which occur in the genus *Hymenostilbe*. In the description given by the Tulasnes of *Torrubia cinerea* the upper part of the stipe is described as glauco-cinereus and delicately pulverulent. This strongly suggests that it also bore conidia similar to those of the Mt. Rainier specimen. There does not appear to be sufficient evidence at present to justify connections between *Hirsutella eleutheratorum*, *Stilbella setiformis* or *Tilachlidiopsis nigra* and *Cordyceps entomorrhiza* (see following discussions under *S. setiformis* and *T. nigra*). It is possible, however, that there may be several species very similar in morphology in the ascogenous condition but differing in conidial stages.

STILBELLA SETIFORMIS (Vahl) Petch. Petch (1933) based his description of this species on specimens no. 1010 and 1218 of Rabenhorst's Fungi Europaei. As has been stated he, at first, considered it to be the conidial stage of *Cordyceps entomorrhiza*. Later he (1939) concluded that it was the same as *Stilbum ramosum* Peck and was not a conidial stage of *Cordyceps entomorrhiza* but a parasite of entomogenous fungi. Rabenhorst's Fungi Europaei 1010 from the Mycological Collections United States Bureau Plant Industry[3] is labeled *Torrubia* (*Cordyceps*) *cinerea* Tul. It contains

[3] The writer is indebted to John A. Stevenson for the loan of specimens from the Mycological Collections of the Bureau of Plant Industry.

a beetle larva with a clava of *Cordyceps entomorrhiza*. The following statement occurs on the label "Fruchtragende Stiele bisweilen, unfruchtbare immer mit einem kleinen keulenförmigen Pilz (Isaria? order Onygene?) besetzt, welcher in grösserer Vollkomenheit sich selbstandig auf dem todten Insect, oder auf dem Cordyceps kopf entwickelt, im jungen Zustande weiss, spater geblich-braun erscheint." This clavate fungus was not found in the specimen from the Bureau of Plant Industry.

Rabenhorst Fungi Europaei 1218 is labeled *Cordyceps entomorrhiza* Fr. forma *spermatophora*. The following statement occurs on the label. "Die typische Schlauchform zu finden gelang uns zeiter nicht obleich wir die Spermatienform zu verschiedenen Zeiten mehrere Jahre lang sammelten." The following description has been prepared from the specimen from the Mycological Collection of the Bureau of Plant Industry.

Synnemata several from the posterior portion of a lepidopterous larva (fig. 3), simple or branched, up to 18 mm. long, the stipes 0.5 mm. thick, ochraceous, capitate, the heads terminating the branches, globoid to obovoid, reddish; phialides subulate terminal and lateral on slender conidiophores, loosely united to form a hymenium covering the heads (fig. 4), 10–20 ×1 μ, acuminate; conidia ellipsoid or oblong, 2–2.5 × 1.5 μ, rounded at the ends, agglutinated in large masses.

On lepidopterous larvae rarely on pupae in woods near Leipzig, Germany, Auerswald and Delitsch, Rabenhorst Fungi Europaei 1218.

A comparison of this specimen with the type of *Stilbum ramosum* has resulted in the conclusion that the two fungi are the same species as Petch decided. However, his conclusion that two fungi are involved, one parasitic on the other, is questionable. In his discussion of the two Rabenhorst collections Petch states that "Conidial clavae also occur as lateral branches on the stems of the *Cordyceps* clavae, and thus establish the relationship between the two forms." This statement must be based on number 1010. According to the statement on the label of number 1010, a stilbaceous fungus had been found independently of the perithecial clavae and sometimes arising from them. Unfortunately the specimen of number 1010 studied by the writer has only a clava of *Cordyceps entomorrhiza* without stilbaceous synnemata. A study of the type specimen of *Stilbum ramosum* has resulted in the conclusion (Mains 1948) that it is a species of *Polycephalomyces*, a genus established for stilbum-like fungi with polycephalous synnemata. From the study of Rabenhorst 1218 it also appears that only one fungus is involved which has polycephalous synnemata and is *Polycephalomyces ramosa* (Peck) Mains. Petch in his discussion of conidial size following the description of *Stilbella setiformis* mentions only no. 1218 suggesting that conidia were lacking in 1010. Whether the stilbaceous fungus of number 1010 is the same as that of number 1218 is uncertain.

Peck (1874) stated that *Stilbum ramosum* occurred on dead larvae of insects in buried wood. The host does not occur with the type specimen. Previously it was suggested (Mains 1948) that it might be coleopterous. It now seems certain the species infects lepidopterous larvae.

TILACHLIDIOPSIS NIGRA YAKUSIJI & KUMAZAWA. The genus Tilachlidiopsis was proposed by Keissler (1924) with the type species *T. racemosa* Keissler. It is described as having brown rhizomorph-like synnemata with lateral branches which are brown below and lighter colored above and which terminate with pallid heads covered with a palisade of phialides. It is reported as occurring on soil among decaying roots of Abies, possibly from insects. *Clavularia hippotrichoides* Lindau which occurs on insects (*Nabis ferus*) was transferred to *Tilachlidiopsis.*

Yakusiji and Kumazawa (1930a) described a species as *Isaria nigra* on beetles in Japan. Since the species has characters given for the genus *Tilachlidiopsis* they (1930b) later transferred it. As has been stated Kobayasi found it associated with immature perithecia resembling those of *Cordyceps entomorrhiza.* Petch (1939) concluded that two fungi were probably involved, a Stibella parasitic on *Cordyceps* clavae. He also suggested that *Tilachlidiopsis hippotrichoides* might be a similar combination. This raises a question concerning the validity of the genus *Tilachlidiopsis.*

A collection of *T. nigra* by Yakusiji and Kumazawa in 1930 from the type locality (Koishikawa Botanical Gardens, Japan) borrowed from the Mycological collections of the U. S. Bureau of Plant Industry[3] has been available for study (figs. 5 & 6). This has a number of larvae and adult beetles having synnemata arising mostly from the ends. The synnemata are 3–7 cm. long and up to 1 mm. thick, flexuous, brownish to purplish black and much branched. A few branches produced secondary branches. The ultimate branches are 2–5 mm. long, 0.1 mm. thick and capitate with spherical or obovoid heads, 250–300 × 200–300 μ. The branches and heads are brown. The phialides are hyaline, cylindric, 10–16 × 2 μ and form a compact hymenial layer over the heads. The conidia are hyaline, cylindric, 8–12 × 1.5–2 μ. They appear to be without a mucus. As far as could be determined from the dried specimens the capitate branches have the same structure as the main stem and appear to be true branches of it. The illustration given by Kobayasi (1937) showing an immature perithecial head from which several capitate conidial branches arise appears to be the evidence upon which Petch based his conclusions that two fungi, one parasitic on the other, were involved. This, however, may represent arrested perithecial development followed by a renewal of the growth of the conidial branches. This appears to be a species with much branched synnemata infecting coleopterous insects. Unless other evidence to the contrary is obtained it seems best to recognize the validity of the genus *Tilachlidiopsis.*

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TILACHLIDIOPSIS SCARABAEI sp. nov. (fig. 7). Synnemata 0.5–2.0 mm. longa, ramosa vel interdum simplicia, polycephala; stipites 90–200 μ crassi, deorsum fuliginei, sursum pallide brunnei vel albi; ramuli breves, pallide brunnei vel albi; capitula globosa vel obovoidea, 170–300 × 120–270 μ, pallide brunnea vel alba, hymeniis phialidium tecta; phialides subcylindricae, 10–14 × 2.5 μ; conidia subcylindrica 4.5–6.5 × 1.5–2 μ, hyalina.

In imagine scarabaei, Desplaines, Illinois, 4-22-1950, Frank Sturtevant, in Herb. Univ. Mich.

Synnemata 0.5–2.0 mm. long, branched or sometimes simple, polycephalous, the stipes 90–200 μ thick fuliginous below, light brown or white above, the branches short, light brown or white, the heads globose or obovoid, 170–300 × 120–270 μ, light brown or white; phialides in a compact hymenium covering the heads, subcylindric, 10–14 × 2.5 μ; conidia subcylindric, 4.5–6.5 × 1.5–2 μ, hyaline.

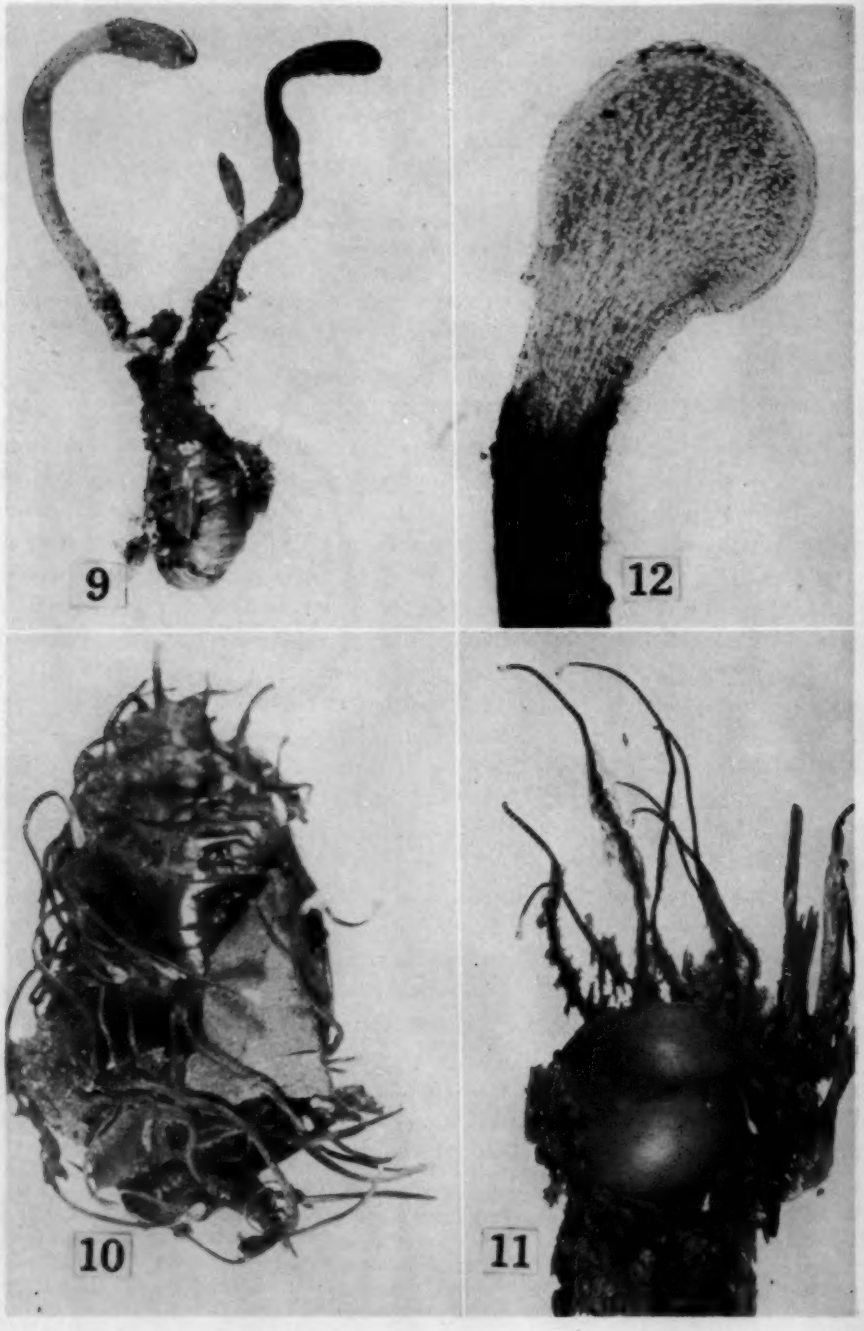
From an imago of a beetle, Carle Woods in leaf mold, Desplaines, Cooke Co., Illinois, 4-22-1950, Frank Sturtevant.

This collection was received from Dr. Maxwell S. Doty. It differs from *T. nigra* in that the synnemata do not have the extensive development of that species and in the size of the conidia. *T. scarabaei* occurs on a much smaller beetle than *T. nigra*. Size of synnemata may be to some extent correlated with the difference in size of hosts but it is doubtful that it would produce the differences which occur in these species. The conidia of *Isaria nigra* were originally described as cylindric 3.5–5 × 0.8–0.9 μ by Yakusiji and Kumazawa (1930a). This must have been an error since when Yakusiji and Kumazawa (1930b) transferred the species to *Tilachlidiopsis* they gave the measurement as 7–10 × 2 μ. Kobayasi (1941) gives the measurements as 10–12 × 1.7–2 μ rarely 4.2–7 × 2.1–2.8 μ. The measurements of spores of the specimen in the Mycological Collections of the U. S. Bureau of Plant Industry collected in the type locality by Yakusiji and Kumazawa were found to be 8–12 ×1.5–2 μ.

The development of the synnemata of *T. scarabaei* resembles that illustrated by Keissler (1924) for *T. racemosa*. However, the conidia of the latter as given by Keissler are much larger, 9–12, rarely 18 ×3–5 μ. The conidia of *T. hippotrichoides* (*Clavularia hippotrichoides*) are given by Lindau (1908) as 7.7–9.6 × 1.5 2 μ and the host is reported by Keissler (1924) as *Nabis ferus* (Hemiptera).

CORDYCEPS SOBOLIFERA HILL EX SACC. (fig. 9). Clavae subclavate, 2–3.5 cm. long, light buff, simple or with short lateral branches which easily become detached, the stipe 1.5–2 mm. thick, the ascogenous portion terminal,

FIGS. 5 & 6. *Tilachlidiopsis nigra* collected by Yakusiji and Kumazawa in Japan. FIG. 5. Much branched synnemata arising from a beetle. × 2.5. FIG. 6. Upper portion of a synnema showing branches and terminal sporogenous heads. × 6. FIG. 7. *Tilachlidiopsis scarabaei*, type, showing a synnema with a few short branches. × 25. FIG. 8. *Isaria cosmopsaltriae*, Lloyd Myc. Coll. 42596, showing two synnemata bearing conidia on the terminal portions and on the irregular lateral branches. ×2.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7–8 mm. long, 2.5–3 mm. thick, the lateral branches fusoid 2–3 × 1.5–2 mm.; perithecia embedded except for the slightly projecting ostioles, conoid or narrowly flask-shaped, 550–650 × 180–230 μ, embedded in a loosely interwoven stroma; asci cylindric, up to 400 μ long, 5–7 μ wide, the wall thin, thickened into a hemispherical cap at the apex, 3 μ thick; ascospores filiform, breaking into one-celled part-spores, 6–12 × 1–1.5 μ; conidial stage produced on the lateral branches from a loose mycelial covering; conidiophores forming a tangled mat; phialides arising directly as lateral cells or terminating short branches of a few cells forming small heads, obovoid, often acute at the apices, 4–5 × 2 μ; conidia abundant, subsylindric, 6.2–8.5 × 2 μ, rounded at the ends.

On *Diceroprocta olympusa* in sandy soil under *Pinus taeda*, G'ville-Colclaugh Hill, Alachua Co., Florida, Aug. 15, 1944, T. H. Hubbell.

As far as the writer is aware, this is the first report of the species from the United States. In North America it has hitherto been reported from the West Indies and Mexico.

The species is unusual in that it may produce ovoid to fusoid lateral or terminal branches, soboles, which may easily become detached and which bear the conidial stage. Conidia also develop on terminal portions of immature clavae and on short irregular lateral branches which do not become detached. Petch (1942) has concluded that the conidial stage is *Isaria cicadae* Miq. Kobayasi (1941) has questioned this since although *I. cicadae* (*I. sinclairii*) occurs in Japan it has not been found associated there with the perithecia of *C. sobolifera*. Instead he reports pycnidia associated with the ascogenous stage. A specimen of *Isaria cosmopsaltria* (=*I. sinclarii* = *I. cicadae*) from Japan in the Mycological Collections of the U. S. Bureau of Plant Industry (Lloyd Mycol. Coll. 42596) has been studied (fig. 8). This is very similar to the conidial fructifications found associated with *Cordyceps sobolifera*. The conidial stage of the specimen from Florida is similar to that reported by Petch as *Isaria cicadae* and supports Petch's conclusion that it is the conidial stage of *Cordyceps sobolifera* which was originally described from the West Indies.

STILBUM BURQUETII MONT. & ROBIN (figs. 10–12). Synnemata arising mostly from the ventral surfaces of the hosts, sometimes creeping along the substratum, less frequently arising from the sutures on the doral surface, 5–20 mm. long, simple, capitate, the heads globoid to obovoid, 0.5–1.0 × 0.5–0.8 mm., cream colored, the stipes cylindric, 0.2–0.3 mm. in diam., brownish black below, concolorous with the head in the upper portion, setose due to scattered brown hyphae up to 150 μ long; phialides forming a compact

FIG. 9. *Cordyceps sobolifera* showing two clavae bearing perithecia in the terminal portions and with a conidial branch, sobole. × 2. FIGS. 10–12. *Stilbum burquetii*. FIG. 10. Lloyd Myc. Coll. 42593 showing many capitate synnemata arising from the ventral surface of a beetle. × 4. FIG. 11. Lloyd Myc. Coll. 42615 showing synnemata appressed to the substratum. × 3. FIG. 12. Lloyd Myc. Coll. 42593 showing the bicolored condition of the terminal portion of a synnema and the hymenial layer covering the head. × 45.

hymenial layer over the surface of the head arising from repeatedly branching hyphae, subcylindric, 16–26 × 2.5–3 μ, hyaline; conidia obovoid to ellipsoid, 6–10 × 2.5–4 μ, hyaline, agglutinating in large masses.

Brazil: on beetles, Rev. J. Rick, Lloyd Myc. Col. 42615, 42579, 42593, Mycol. Coll. U. S. Bur. Plant Ind.[3]

Bolivia: On *Erotylus spectrum*, Mulford Bio. Expl. 1921–1922. Isiamas, December, W. M. Mann (Mich.).

The specimens from Brazil were reported by Lloyd (1922) as *Isaria briquetii* (apparently in error for *I. buquetii*). The specimen from Bolivia was received from Donald P. Rogers who found it among undetermined collections in the Farlow Herbarium.

The synnemata are bicolored. In the dried specimens the heads and upper portions of the stipes are cream-colored and the lower portions of the stipes brownish black (fig. 12). It is probable as in a number of other species of entomogenous fungi having bicolored synnemata or clavae that the cream-colored portion was red or orange when fresh. Spegazzini (1889) described a bicolored species, *Isaria melanopus*, on beetles from Apiahy Brazil. The stipes are described as black, pallid above, and the heads as carneo-aurantius. The phialides are given as cylindric 10–15 × 3μ and the conidia as elliptical or obovate-cylindric, 5–10 × 3–4 μ This is apparently the same as *Stilbum buquetii*.

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THE AMINO ACID AND VITAMIN REQUIREMENTS OF CANDIDA ALBICANS Y-475 AND MYCODERMA VINI Y-939

ILDA MCVEIGH AND EMILY BELL[1]

During investigations of the nutritional requirements of 163 strains and species of yeasts by Burkholder (1943), Burkholder and Moyer (1943) and Burkholder, McVeigh and Moyer (1944), only two were found which failed to grow when subcultured on a minimal medium composed of mineral salts, dextrose and asparagine supplemented with vitamins. These two: *Candida albicans* Y-475 and *Mycoderma vini* Y-939, grew very satisfactorily when an extract of liver was added to the above medium. The purpose of the present investigation was to determine the nutritional requirements of these two yeasts.

Methods and Materials. Stocks were maintained by weekly transfers on glucose–peptone medium. These cultures were incubated at 30° C until abundant growth had occurred, and were then stored in the refrigerator. Unless otherwise stated, the minimal medium employed in the determination of the growth requirements of these two organisms contained the following per liter of solution: glucose, 20.0 g.; KH_2PO_4, 1.5 g.; $MgSO_4 \cdot 7H_2O$, 0.5 g.; $CaCl_2 \cdot 2H_2O$, 0.33 g.; $(NH_4)_2SO_4$, 2.0 g.; KI, 0.1 mg.; and recrystallized asparagine, 2.0 g. To this solution the following minor mineral elements were added in parts per million: B, 0.005; Mn, 0.01; Zn, 0.09; Cu, 0.02; Mo, 0.01; and Fe, 0.1. The pH was adjusted to 4.5–5.0.

Stock solutions of the various supplements were made in distilled water and adjusted to a pH of approximately 7.0. Suitable dilutions of these were added in measured amounts to the culture tubes. The minimal medium at twice the concentration of the dissolved materials mentioned above was distributed in these tubes in amounts equal to one-half of the final volume; subsequently sufficient distilled water was added to each to give the final desired concentration. After the tubes were plugged with cotton they were sterilized with steam at 15 pounds pressure for 15 minutes.

The inoculum of *C. albicans* was prepared by transferring a small mass of cells from a 48-hour stock culture into sterile distilled water: for

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We are indebted to the Natural Science Research Fund for some of the equipment used in this investigation.

M. vini, cells from a 96-hour stock culture were used. Each suspension was shaken vigorously to wash the cells, and the supernatant liquid was decanted after centrifugation. Uniform suspensions were then made by adding 5 ml. of sterile water to each tube. This procedure seemed to be sufficient to free the inocula from any growth factors which might interfere with the results. One drop of this suspension was added aseptically to each tube of medium by means of a sterile pipette. Triplicate sets of tubes were inoculated and a fourth set, not inoculated, served as a control. After inoculation the tubes were shaken and then incubated at 30° C. During incubation they were shaken daily to effect aeration. After a sufficient period, which is stated later for individual experiments, growth was measured turbidimetrically by use of a Klett-Summerson photoelectric colorimeter. After correction for the turbidity of the uninoculated medium, average values were computed for each set of cultures.

Those amino acids which were available only as mixtures of the natural and unnatural isomers were used in amounts twice that indicated in the text for the natural forms. A vitamin mixture was made to contain per 100 ml. of solution 10,000 mμ moles each of thiamin hydrochloride, pyridoxine hydrochloride, nicotinic acid, calcium pantothenate, para-aminobenzoic acid and riboflavin; 10,000,000 mμ moles of i-inositol; 1,000 mμ moles of pteroylglutamic acid; and 1.0 μg. of biotin methyl ester. Whenever employed, this mixture was added in amounts of 10 ml. per liter of the final volume of the culture medium. The casein hydrolysate supplement was a 10% solution of "special" casein hydrolysate prepared commercially by General Biochemicals, Incorporated. Inasmuch as most of the cystine and trytophane occurring in casein is destroyed during the process of hydrolysis, these two amino acids were added at a rate of 1.0 μg. of each whenever a milligram of casein hydrolysate was used. The solution of animal protein factor was a product of Lederle Laboratories, labeled APF-60. The liver supplement was obtained from the Armour Laboratories and is sold under the name Crude Liver Liquid Parenteral.

Results. *Nature of growth factor requirements.* To ascertain the general nature of the requirements of these organisms, that is, whether they require one or more of the water soluble vitamins, one or more of the amino acids, some unknown growth factor or factors contained in the liver supplement, or possibly some combination of these substances they were inoculated into the following media: minimal; minimal plus vitamin mixture; minimal plus casein hydrolysate; minimal plus liver supplement; minimal plus vitamin mixture and casein hydrolysate; minimal plus vitamin mixture, casein hydrolysate and liver supplement. After a suitable period of growth, average turbidity readings showed that the addition of both vitamins and amino acids was necessary for the growth of each of the organisms. The addition of the

liver extract to the minimal medium supplemented with casein hydrolysate and the vitamin mixture resulted in considerable improvement in the growth of *M. vini*. However, the same amount of liver extract did not increase growth significantly when it was the only supplement added to the minimal medium. This indicated that some growth factor or factors in the liver extract other than those contained in the casein hydrolysate or in the vitamin mixture, while not essential for the growth of the organism, stimulated it; or else some factor, or factors, contained in the vitamin mixture or casein hydrolysate had not been added in optimum amounts. Liver extract is known to contain amino acids and vitamins as well as other factors. If, in the medium supplemented with the vitamin mixture and the casein hydrolysate, one or more of the compounds in these supplements was not present in concentration sufficient to produce maximum growth, the liver extract might augment them and thus increase the growth of the organism. By increasing the amount of casein hydrolysate added to the minimal medium supplemented with the vitamin mixture from 1.0 mg./ml. to 4.0 mg./ml., growth of *M. vini* equal to that obtained in the minimal medium supplemented with the vitamin mixture, casein hydrolysate (1.0 mg./ml.) and liver extract (0.001 ml./ml.) was obtained. Increasing the amount of casein hydrolysate to 10.0 mg./ml. resulted in no better growth than that which occurred with 4.0 mg./ml. In subsequent experiments with *M. vini* in which casein hydrolysate was used it was added at the rate of 4.0 mg./ml.

Optimum concentration of asparagine and glucose. It seemed advisable to make certain that the amounts of asparagine (2.0 g./l.) and glucose (20.0 g./l.) contained in the minimal medium were sufficient for maximal growth of each of the organisms before making further determinations of the vitamin and amino acid requirements. Therefore each organism was grown in the minimal medium supplemented with casein hydrolysate and the vitamin mixture with varying concentrations of asparagine and glucose. Asparagine at a concentration of 2.0 g./l., the amount ordinarily used in the minimal medium, was sufficient for maximum growth of each of the organisms. Glucose in the amount usually employed in the minimal medium was optimum for the growth of *C. albicans*, but insufficient for *M. vini*. Results indicated that 50.0 g./l. were needed for the maximum growth of *M. vini* and, accordingly, in all subsequent experiments this amount was added to the minimal medium for this organism.

Requirements for specific amino acids. To determine which amino acids are required, that is, which of the nineteen amino acids known to be contained in casein hydrolysate must be added to the minimal medium to insure growth, a series of twenty-one media were employed. Two of these were controls, (1) the minimal medium and (2) a complete medium which consisted of the minimal medium supplemented with casein hydrolysate and

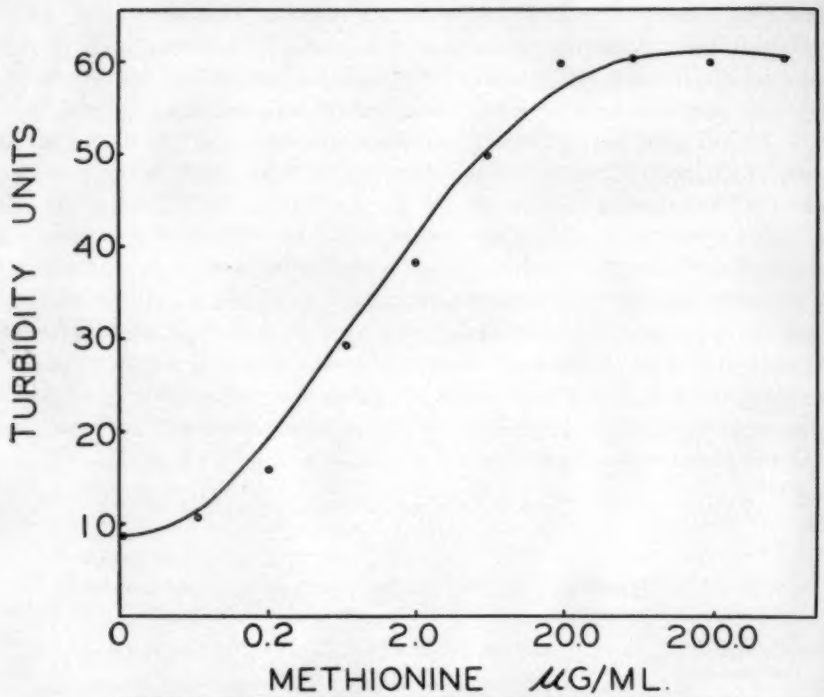
the vitamin mixture. Each of the remaining nineteen sets of tubes contained the vitamin mixture and all but one of the amino acids known to be present in casein; the specific amino acid omitted in each set is indicated in table 1. The eighteen which were present in each tube were added at a concentration of 0.22 mg. of each per ml. for *C. albicans* and 0.4 mg. of each per ml. for *M. vini*. The vitamin mixture was added to the basal medium used in each of these nineteen sets of tubes.

Table 1 gives the results of this experiment. Growth of *C. albicans* in all of the media which contained mixtures of the amino acids except the one in which methionine was omitted approached that in the complete medium; growth in the absence of methionine was poor, thus indicating a deficiency for this amino acid. No growth occurred in the minimal medium. *M. vini* was found to be deficient for cystine. Growth in the absence of each of the other amino acids approached that in the complete medium, but was much less in the absence of cystine.

TABLE 1. *Growth after 72 hours in a chemically defined medium*

Medium	Average Turbidity	
	C. albicans	*M. vini*
Minimal medium	0	2
Complete medium	93	38
" " —alanine	68	38
" " —aspartic acid	73	36
" " —arginine	79	36
" " —cystine	72	16
" " —glutamic acid	85	36
" " —glycine	70	36
" " —histidine	78	35
" " —hydroxyproline	73	37
" " —isoleucine	81	35
" " —leucine	70	35
" " —lysine	80	37
" " —methionine	42	37
" " —phenylalanine	68	27
" " —proline	89	37
" " —serine	66	37
" " —threonine	73	36
" " —tryptophane	80	37
" " —tryosine	71	37
" " —valine	70	35

The amount of methionine required for the optimum growth of *C. albicans* was determined by growing the organism in the minimal medium supplemented with the vitamin mixture and increments of this compound. The results shown graphically in figure 1 indicate that maximum growth was obtained with methionine at a concentration of 20.0 μg./ml. Increasing the amount to 1000 μg. did not improve growth significantly. Growth with methionine, as the only amino acid supplied in the medium, equalled that



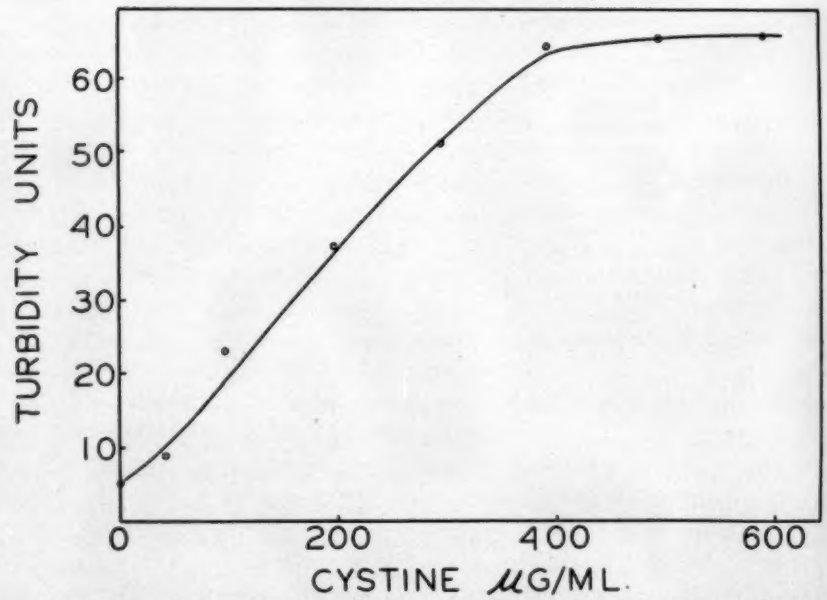


FIG. v (above). Graph showing the growth response of *C. albicans* to increasing amounts of methionine. Turbidity readings were made after a growth period of 72 hours. FIG. 2 (below). Graph showing the growth response of *M. vini* to increments of cystine. Turbidity readings were made after a growth period of 120 hours.

obtained with casein hydrolysate. In a similar manner the amount of cystine required for the optimum growth of *M. vini* was found to be 0.4 mg./ml. (fig. 2). Increasing the cystine to 5.0 mg./ml. resulted in no better growth. With cystine, as the only amino acid supplied, growth was equal to that in the control.

Requirements for specific vitamins. For the determination of the particular vitamin deficiency or deficiencies, eleven types of media were prepared, two of which served as controls. One set of controls contained the minimal medium, the other was a complete medium composed of the minimal medium supplemented with casein hydrolysate and the vitamin mixture. The basal medium for the other nine sets consisted of the minimal medium supplemented with casein hydrolysate (1.0 mg./ml. for *C. albicans* and 4.0 mg./ml. for *M. vini*). To each of these, eight of the nine vitamins contained in the vitamin mixture were added; a different vitamin was omitted from each set. The vitamins were added to give the following amounts per ml. of medium: biotin, 0.0015 μg.; pteroylglutamic acid, 1.5 μg.; thiamin hydrochloride, 0.6 μg.; riboflavin, 0.6 μg.; calcium pantothenate, 0.6 μg.; inositol, 0.6 μg.; para-aminobenzoic acid, 0.6 μg.; nicotinic acid, 0.6 μg.; and pyridoxine hydrochloride, 0.6 μg.

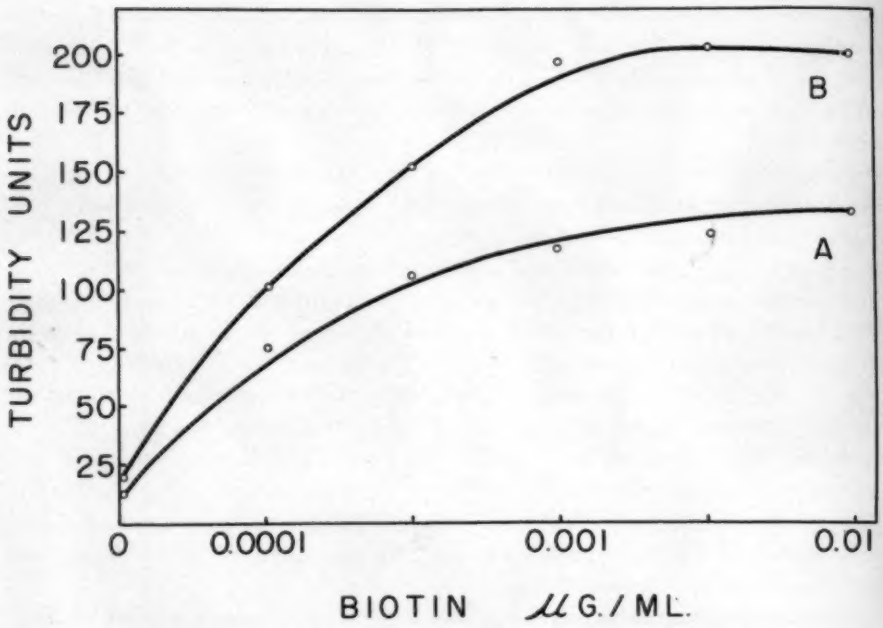
The average turbidity readings obtained after a growth period of three days are given in table 2. Growth of *C. albicans* was much less in the absence

TABLE 2. *Growth after 72 hours in the absence of various vitamins*

Medium	Average Turbidity	
	C. albicans	*M. vini*
Minimal medium	4	8
Complete medium	137	40
" " —thiamin	28	39
" " —riboflavin	121	36
" " —pantothenic acid	137	34
" " —pyridoxine	128	40
" " —para-aminobenzoic acid	130	40
" " —nicotinic acid	137	39
" " —pteroylglutamic acid	132	41
" " —biotin	36	10
" " —inositol	125	38

of thiamin and biotin than in the complete medium, indicating deficiencies for these two vitamins. Biotin was found to be essential for the growth of *M. vini* also. In the absence of each of the other vitamins growth approached that in the complete medium.

The optimum concentration of each of the vitamins required by *C. albicans* and *M. vini* were determined in a manner similar to that described for the amino acids. The results shown in figures 3 and 4 indicate that biotin at



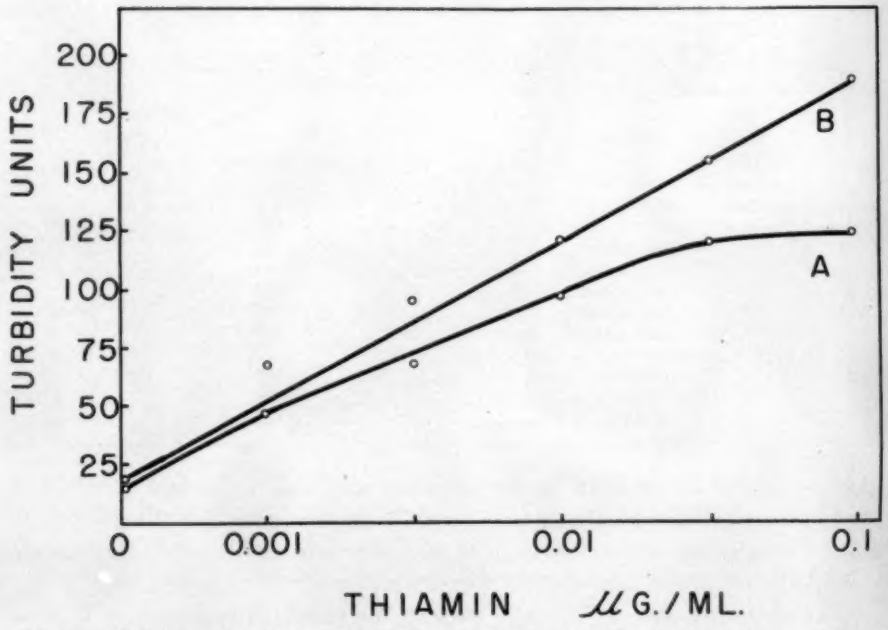


FIG. 3 (above). Graph showing the growth response of *C. albicans* to increments of biotin. Turbidity readings were made after growth for 24 hours (Curve A) and 48 hours (Curve B). FIG. 4 (below). Graph showing the effect of increments of thiamin on the growth of *C. albicans*. Turbidity readings were made after growth periods of 24 (Curve A) and 48 hours (Curve B).

a concentration of 0.005 μg./ml. and thiamin at a concentration of 0.1 μg./ml. supported maximum growth of *C. albicans* under the conditions investigated. Since the curve for thiamin (fig. 4) obtained from the turbidity reading at the end of 48 hours was a straight line curve it seemed possible that by increasing the amount of thiamin above 0.1 μg./ml. a further increase in growth might result. However, in an experiment similar to that described above, it was found that no additional growth could be obtained by increasing the amount of thiamin to 1.0 μg./ml. Therefore, it was concluded that 0.1 μg./ml. of thiamin is sufficient to allow maximum growth of *C. albicans*. For *M. vini* it was found that biotin at a concentration of 0.005 μg./ml. was sufficient to give maximum growth in the medium employed (fig. 5).

To further verify these results growth of each organism on a complete synthetic medium was compared with that on a complete natural medium. The results obtained are shown in table 3. The complete synthetic medium for *C. albicans* consisted of the minimal medium supplemented with methionine (20.0 μg./ml.), biotin (0.005 μg./ml.) and thiamin (0.1 μg./ml.); while the natural medium contained the minimal medium plus casein hydrolysate (1.0 mg./ml.), vitamin mixture (0.01 ml./ml.) and Difco neopeptone (2.0 mg./ml.). Growth of this organism in the natural medium at the end of 24 and 48 hours was better than that in the synthetic medium, but at the end

TABLE 3. *Growth in the minimal medium, a complete natural medium, and a complete synthetic medium*

Medium	Average Turbidity			
	C. albicans			*M. vini*
	24 hrs.	48 hrs.	72 hrs.	120 hrs.
Minimal medium	1	1	1	2
Complete (natural)	58	181	191	128
Complete (synthetic)	30	136	198	125

of 72 hours there was no difference, indicating that a longer period of adaptation is required in the synthetic medium. The complete synthetic medium for *M. vini* consisted of the minimal medium supplemented with cystine (0.4 mg./ml.) and biotin (0.005 μg./ml.); while the natural medium contained the minimal medium plus casein hydrolysate (4.0 mg./ml.), the vitamin mixture (0.01 ml./ml.), and liver extract (0.001 ml./ml.). After a period of five days, growth in the complete medium was equal to that in the natural medium (table 3).

Discussion. It is interesting to note that of over 150 species and strains of naturally occurring yeasts included in the investigations by Burkholder and coworkers only two completely failed to grow in the minimal medium composed of mineral salts, dextrose and asparagine supplemented with a

mixture of water soluble vitamins (Burkholder 1943, Burkholder and Moyer 1943, Burkholder, McVeigh and Moyer 1944). The growth of several others was improved by the addition of an extract of liver. The present study indicates that these two, *Candida albicans* Y-475 and *Mycoderma vini* Y-939, are each deficient for certain of the vitamins and amino acids. The ability of yeasts to utilize ammonium sulfate, urea, asparagine and peptone was used by Lodder (1934) and Langeron and Guerra (1938) in the classification of yeasts. Wickerham (1946) found that all of the yeasts he tested which had previously been designated by other workers as incapable of assimilating

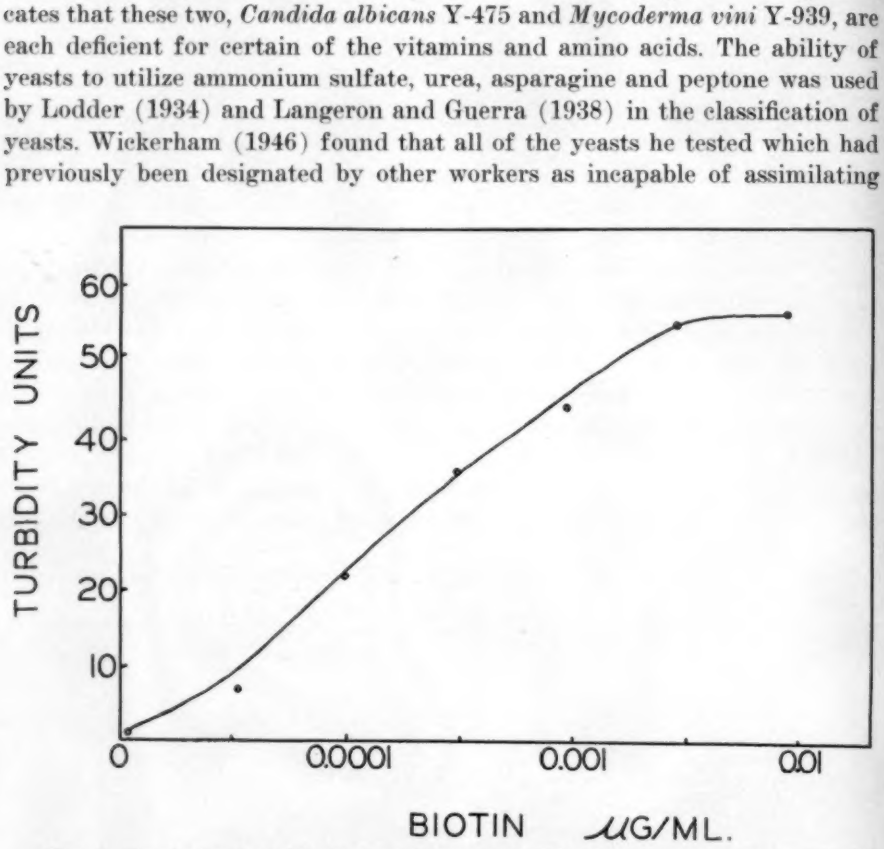


FIG. 5. Graph showing the effect of increments of biotin on the growth of *M. vini*. Turbidity readings were made after an incubation period of 120 hours.

ammonium sulfate, urea and asparagine were able to do so when given an adequate supply of pure vitamins. He pointed out that these earlier tests instead of indicating species differences in the utilization of the sources of nitrogen, actually indicated species differences in the ability to synthesize certain vitamins. However, the two species included in the present study failed to grow with asparagine and ammonium sulfate as the only sources of nitrogen even in the presence of an adequate supply of vitamins.

In 1949 Foster stated, "So far as is known, no fungus has a natural absolute requirement for a specific amino acid in the sense that it lacks the ability to synthesize this particular amino acid meanwhile synthesizing all

the other cellular constituents," and he further states, "There is no record of a requirement for amino acids similar to those among the lactic acid bacteria." Contrary to Foster's statements are the reports of Schopfer and Guilloud (1945) in which l-leucine and d-arginine were found indispensible in a synthetic culture medium for *Eremothecium Ashbyii;* of Melin and Mikola (1948) and Mikola (1948) in which lysine, methionine, and especially histidine proved to exert a significant growth-promoting activity on *Cenococcum graniforme;* and of Fries (1949) in which three species of *Mycena* were shown to have partial or complete deficiencies for phenylalanine and/or tyrosine. The present work adds two species of fungi to the list of those shown to be deficient or partially deficient for specific amino acids. That the requirements of *C. albicans* Y-475 for amino acids can be supplied adequately by the addition of a single amino acid, methionine, and that of *M. vini* Y-939 by the addition of cystine alone to the minimal medium supplemented with vitamins is shown in table 3; and that these requirements can not be synthesized by these organisms in amounts sufficient for optimum growth even in the presence of other amino acids can be seen from the data presented in table 1. Tatum (1944) working with *Neurospora,* Fries (1948) with *Ophiostoma* and Pomper and Burkholder (1949) with *Saccharomyces* have shown that among mutants produced artificially, deficiencies for amino acids occur rather frequently.

It will be recalled that Schopfer (1944) reported a strain of *C. albicans* deficient for both biotin and thiamin. Included among forms studied by Burkholder (1943), Burkholder and Moyer (1943), Burkholder, McVeigh and Moyer (1944) were six strains of *C. albicans* in addition to the one included in this study. All of these were found to be deficient for biotin and partially or completely deficient for thiamin. Of the 35 species and strains of *Candida* included in their studies only three were autotrophic for the B vitamins. Of the remainder all but one was deficient for biotin and of these, 19 also showed either a partial or a complete deficiency for thiamin.

The long stationary phase of growth of biotin deficient yeasts, observed by Wingler, Burk and de Vigneaud (1944) was noted in the rate of growth of these two yeasts. Rapid growth did not begin until after 24–30 hours of incubation for *C. albicans* and 48–60 hours for *M. vini.* Koser, Wright and Dorfman (1942) found that biotin could be partially replaced by dl or l-aspartic acid for *Torula cremoris.* In the present study it was found that aspartic acid could not replace biotin for either of the yeasts studied; the latter must be added to the medium even when aspartic acid is present.

Although all of the growth factors required by these organisms are sulfur-containing compounds, their function does not seem to be one of supplying sulfur since other sulfur compounds did not replace them in furnishing the requirements for maximum growth. It is quite probable that

they act as integral parts of enzyme systems rather than as building stones for protein.

SUMMARY

1. *Candida albicans* Y-475 required, for maximum growth, the addition of 0.005 μg./ml. of biotin, 0.1 μg./ml. of thiamin, and 20.0 μg./ml. of methionine to a chemically defined medium. Glucose at a concentration of 20.0 g./l. was sufficient for the maximum growth of this organism.

2. *Mycoderma vini* Y-939 required the addition of biotin at a concentration of 0.005 μg./ml. and cystine at a concentration of 0.4 mg./ml. to a chemically defined medium for maximum growth. Fifty grams per liter of glucose were required for the best growth of this organism.

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STUDIES OF MONOSPOROUS CULTURES OF POLYPORUS CINNABARINUS FR.

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In November, 1946, several fresh sporophores of *Polyporus cinnabarinus* Fr. were collected near Huntington, Long Island, New York. Two were used in the experiments reported here and were designated as follows: specimen A, found on a fallen oak log; specimen F, found on another oak log about one-half mile from specimen A.

Single-spore cultures were obtained by allowing spores to drop onto the surface of potato-dextrose-agar in a Petri dish. Incubation overnight or longer at 28° C. allowed the spores to germinate. Single spores situated some distance from others were located under low power of the microscope, and small pieces of agar bearing the single spores were cut out while the operator watched proceedings through the microscope. The bits of agar and spore were transferred to slants of potato-dextrose-agar for incubation at 28° C. until such time as experiments were started.

Results of pairings. Mycelia from the same sporophore. Microscopic examination of these isolates showed that none bore clamp-connections, so it was assumed that all were monocaryon. Twenty of the cultures from specimen A were used in study of the number of sexual phases existent among spores of this specimen. The twenty cultures were paired in all possible combinations in Petri dishes on potato-dextrose-agar. One day after any two cultures had come into contact the hyphae at the line of union were examined for clamp-connections.

It was found that any particular culture produced clamp-connections when paired with approximately one-fourth of the twenty cultures. It was possible to assign each culture to one of the four sexual groups, *AB, Ab, aB* and *ab*. It is concluded, therefore, that this species was quadripolar.

There were no irregularities in the pairing reaction. No illegitimate diploids were formed, and there was no evidence of the "barrage sexuel" that Vandendries and Brodie described (Vandendries & Brodie 1933).

Since there was no barrage phenomenon that would furnish a basis for letter designations of the factors involved in the pairing behavior, factorial symbols were assigned arbitrarily to the cultures. Later, 10 more monocaryon

[1] The writer thanks the following for advice and help: Dr. Ray F. Dawson, Dr. H. L. Barnett, K. B. Tate.

TABLE 1. *Radii of colonies of monocaryon cultures derived from collection A of P. cinnabarinus. Measurements were made in mm. from the edge of the transfer implanted on the plate to the edge of the colonies. Data were taken after 4 days' incubation on potato-dextrose-agar at 28° C. The figures of the "adjusted average" in the bottom row were secured by dropping or increasing the decimals of each average to the nearest whole figure.*

Plate No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	16	15	10	12	11	10	11	14	12	12	13	12	9	10	15	12	10	12	14	11
2	15	15	10	13	11	11	11	13	12	12	11	12	14	13	14	10	12	14	10	10
3	15	15	10	13	10	10	10	15	13	12	10	14	10	10	13	12	13	14	12	12
4	16	16	11	13	12	10	12	15	12	10	10	12	12	10	12	15	11	15	10	10
5	15	17	9	13	10	13	11	12	11	10	11	12	13	11	15	13	10	12	12	10
6	15	16	10	13	13	11	11	10	12	10	10	13	10	12	13	12	13	13	11	11
7	14	16	10	12	13	11				14	11	11	10	10	15	12	9	16	12	12
8	16	15	14	12	12	11				16	13	11	11	10	15	13	11	13	12	13
9	19	15	10	12	10	11				14	13	12	15	11	14	12	10	13	10	11
10	17	16	12	12	12	11				14	10	14	11	10	15	11	9	13	10	12
11	15	15	6	12	13	11				13	12	11	12	11	15	13	13	12	12	11
12	17	11	12	12	12	11					12	11	13	11	15	14	10	15	11	10
13	18	16	12	14	12	11					13	14	10	11	13	13	10	14	12	12
14	16	15	12	12	12	11					12	11	11	12	13		11	14	9	10
15	17	15	10	13	12						14	13	11					15	14	
16	18	14	11	11	12								12							
Ave.	16.2	15.1	10.6	12.4	11.7	10.8	11.0	13.1	12.0	12.4	11.6	12.2	11.6	10.9	14.0	12.5	10.9	13.7	11.4	11.1
Adj. Ave.	16	15	11	12	12	11	11	13	12	12	12	12	12	11	14	12	11	14	11	11

cultures were paired with one culture from each of the four sexual groups to determine their mating reaction. All of these results are listed as follows:

AB	*Ab*	*aB*	*ab*
A-1	A-3	A-9	A-6
A-2	A-4	A-11	A-7
A-5	A-12	A-13	A-16
A-8	A-27	A-14	A-17
A-10	A-28	A-15	A-20
A-18	A-29		A-23
A-19			A-24
A-21			A-25
A-22			A-26
A-30			

Mycelia from different sporophores. Ten monosporous cultures derived from specimen F were paired with one another. They fell into four sexual groups. All then were paired with one representative of each of the four sexual groups of specimen A. Examination of the pairings revealed the presence of typical clamp-connections in all pairings made. It was concluded, therefore, that in this species multiple allelomorphs of the factors for compatibility exist.

Growth-rates. Monocaryon cultures. One experiment showed that the rate of growth of the culture on potato-dextrose-agar was not correlated with the position of the Petri dish in the stacks of dishes nor with the sexual phase of the isolate.

TABLE 2. *Distribution of monocaryon cultures of collection A of P. cinnabarinus according to average rate of growth and sexual phase and classification of each as a "rapid" or "slow" grower.*

Average Rate of Growth (mm.)	Culture No. (exhibiting rate of growth)	Compatibility Group	Class	
			Rapid Growth	Slow Growth
11	P.C.-3	*Ab*		+
11	P.C.-6	*ab*		+
11	P.C.-7	*ab*		+
11	P.C.-14	*aB*		+
11	P.C.-17	*ab*		+
11	P.C.-19	*AB*		+
11	P.C.-20	*ab*		+
12	P.C.-4	*Ab*		+
12	P.C.-5	*AB*		+
12	P.C.-9	*aB*		+
12	P.C.-10	*AB*		+
12	P.C.-11	*aB*		+
12	P.C.-12	*Ab*		+
12	P.C.-13	*aB*		+
12	P.C.-16	*ab*		+
13	P.C.-8	*AB*	+	
14	P.C.-15	*aB*	+	
14	P.C.-18	*AB*	+	
15	P.C.-2	*AB*	+	
16	P.C.-1	*AB*	+	

The next experiment was devised to determine the rates of growth of monocaryon mycelia as one character that could be studied genetically. Twenty of the monocaryon cultures used in the previous experiment again were grown on Petri dishes of potato-dextrose-agar and fresh plantings of uniform size were made from the edges of the colonies to fresh Petri dishes of the medium. Several transfers were made, one to each Petri dish, of each of the twenty monocaryon cultures used and were incubated for 4 days at 28° C. The rates of growth of the isolates are given in table 1.

Examination of the "adjusted" average revealed the apparent existence of two groups of cultures relative to the rapidity of growth. These groups are shown in table 2.

Since so few of the cultures grew 13 to 16 mm. in the time period and the others grew 11 or 12 mm., it seems likely that two classes of monocaryon cultures, "rapid" and "slow" with respect to rate of growth on Petri dishes on potato-dextrose-agar, do exist. However, a statistical analysis was made of the results to be certain. Student's test was used to determine whether the two normal populations, variance unknown, were the same. The two populations were the group of 5 rapid growers and the group of 15 slow growers. The essential data and steps in Student's test are as follows[1]:

	$\bar{x}$	s
Rapid growers	196.40	98.20
Slow growers	154.46	41.15

$$s^2 = \frac{(N1-1)s_1^2 + (N_2-)\,s_2^2}{N_1+N_2-2} = 3459.86$$

where

s_1^2 = estimate of time variance of x_1
s_2^2 = estimate of time variance of x_2
N_1 = number of x_1 observations
N_2 = number of x_2 observations

$$t = \frac{\bar{x} - x_2}{\left(\frac{N_1+N_2}{N_1+N_2-2}\right) 1/2 \left(\frac{(N_1-1)s_1^2 + (N_2-1)s_2^2}{N_1\,N_2}\right) 1/2} = 2.37$$

where t is distributed in Student's distribution.

The value in Student's distribution table for 18 degrees of freedom at the 5% level is 2.101. Since the t value in the calculations above was greater than 2.101, our figure cannot be accepted as indicating that the means of the two populations are the same; hence, it is likely that they are different populations.

[1] This test was secured from statistical memorandum No. 4, revised edition, Frankford Arsenal, September 1946.

When this experiment was repeated about two years later the results were not the same; four additional isolates would be classed as rapid growers. This variability in replicate tests is similar to the variability found by Lilly and Barnett with *Lenzites trabea* (Lilly & Barnett 1948).

Two questons arise immediately: (1) what features of the physiology of one set allow the isolates to grow more rapidly than do those of the other class, and (2) how can this distribution of 1 rapid grower to 3 slow growers among the monocaryon cultures be explained?

The first question has been studied so far from only one point of view. Since so many Polyporaceae are deficient for thiamine production, it was thought that the "slow-growing" group might be deficient in this regard. An experiment was devised consisting of growing nine monocaryon cultures (2 "rapid," 7 "slow") on a medium of dextrose, asparagine, KH_2PO_4, distilled water and agar with and without added thiamine (1 μg per ml. of medium). The cultures supplied with thiamine grew at the same rate as when no thiamine was added. Thiamine deficiency seems to be ruled out.

To explain the occurrence among the monocaryon cultures of isolates in the ratio 5 rapid: 15 slow the author suggests the following. Assume the existence of a pair of allelomorphic genes *R* and *r*, the *R* allowing rapid growth, the *r* slow growth. Assume also the existence of another pair of allels on another set of chromosomes; these will be designated as *I* and *i*. The presence of *I* will inhibit rapid growth, *i* will allow rapid growth. If the fusion nuclei in the basidia are *IiRr*, chance combinations of the chromosomes at meiosis would result in the formation of four kinds of nuclei in the four basidiospores: *IR, Ir, iR, ir*. Of these the nuclei designated *iR* would allow rapid growth; the other three-fourths of the nuclei would allow slow growth.

Examination of table 2 will show that the rate of growth cannot be correlated with the sexual nature of the culture.

These results would indicate that the factors determining ultimately the rate of growth are on two chromosomes other than the two bearing the *A* or *B* genes or their allels. This would mean that there would be at least 4 chromosomes in the haploid nuclei. This prediction was interesting in view of the fact that Wakayama (1932) reported that *P. cinnebarinus* near Tokyo had a haploid number of four.

Dicaryon cultures. To determine whether there was a detectable physiological effect of the genetic factors determining the rate of growth in dicaryon cultures the following experiment was performed. Fresh cultures of P.C.—1 through P.C.—20 and compatible pairings involving these isolates were grown on Petri dishes of PDA at 28° C. for 4 days. The diameters of the colonies (two measurements of each colony, three colonies on each of two Petri dishes for each culture) were then measured.

Comparison of the averages of the diameters of the colonies showed that of 44 pairings studied 20 dicaryon cultures grew more rapidly than did either of the haplonts from which the dicaryon was derived, 12 grew more rapidly than one of the haplonts involved and 12 grew more slowly than both haplonts involved in any of the particular pairings.

At a later date this experiment was expanded by planting in duplicate on plates of PDA 20 monosporous cultures and *all* pairings, compatible or not, obtained with these. After 5 days' growth at 28° C. two radii of each of the two colonies were measured and the values averaged. The averages of the paired cultures were compared with the haplonts from which they were derived.

The results are summarized as follows:

	Compatible Pairings	Incompatible Pairings
Culture growing faster than either haplont	22	31
Culture growing faster than one haplont	23	76
Culture growing slower than either haplont	4	31
Culture growing at same rate as both haplonts	.....	2

The normal distribution curve secured in the incompatible pairings might be explained by assuming the existence of two pairs of allelomorphic genes determining growth-rates in the population of spores; various combinations would give the growth-rate pattern that develops. This seems unlikely, however, in view of the fact that the various haplonts that grew most rapidly were not capable of producing rapid growers when paired with all other haplonts but only when paired with certain ones. This makes it seem likely that several factors are involved in determining growth-rates.

Dodge (1942) secured somewhat similar results with *Neurospora tetrasperma;* hyphae containing the nuclei of two slow-growing strains of this species grew more rapidly and vigorously.

Fulton (1950) recently showed in *Cyathus stercoreus* that factors other than *Ab* and *ab* must be involved in partially determining the compatibility reaction, even though four compatibility groups were known to exist.

It should be noted that of the seven rapidly growing haplonts involved in incompatible pairings which grew more rapidly than the haplonts from which they were derived six were involved in the *compatible* pairings that grew more rapidly than *their* haplonts. However, these same six or seven did not always cause the progeny to grow more rapidly than either "parent," and, of course, other haplonts would cause the cultures they helped produce to grow more rapidly than either "parent." Evidently the character of growing more rapidly than the "parents" depends upon the interaction of the two genetic systems involved and is not determined exclusively by either one.

The rate of growth of the entire group of pairings ranged from 9 mm. (radius) to 28 mm. The rates of growth, plotted on a graph, showed a normal distribution curve.

Discussion. Differences in rate of growth of monocaryon mycelia have been mentioned in many papers. Hanna (1925) found differences in rate of growth, production of oidia and habit of growth in *Coprinus lagopus*. He also states that Kniep reported for *Aleurodiscus polygonius* that frequently two spores of a basidium germinated and developed mycelia more rapidly than did the other two; in this case the rapid growing mycelia were all of one sexual group.

Lilly and Barnett (1948) reported findings with *Lenzites trabea* that are, in some respects, similar to results given here. They found that monocaryon cultures of this species varied in ability to synthesize thiamine; the results of this could be seen in comparison of dry weights attained in thiamine-free liquid medium. In genetical work they found that dicaryon cultures generally showed an ability intermediate with or inferior to the abilities of the parent cultures. Knowledge of thiamine deficiencies of the monocaryon cultures was insufficient to allow them to predict the deficiencies of the dicaryon cultures derived from the pairings. Unlike our cultures, there was one monocaryon culture which always had the same effect: to cause the dicaryon cultures of which it was one parent to grow more slowly than either parent. They concluded that "... the mode of inheritance of partial thiamine deficiency appears complex."

The results reported here in regard to factors determining rates of growth seem explainable on the basis of the assumption of two pairs of allelomorphic genes that determine rates of growth in monocaryon cultures. However, rates of growth of dicaryon cultures are not so easily explained. Probably they are determined by the interaction of several genes, not just two.

SUMMARY

1. Pairings of thirty monocaryon cultures of *P. cinnabarinus* showed the existence of four compatibility groups.

2. Two classes of monocaryon cultures, "slow" and "rapid" growers, were demonstrated on the basis of rate of growth on potato-dextrose-agar in Petri dishes. The "slow" growers were not slow because of a deficiency of thiamine. Rates of growth could not be correlated with the compatibility group of the culture.

3. In cultures derived from pairing of monocaryon mycelia there was no pattern discernible of how various cultures would influence the rate of growth of a dicaryon culture; the effect of any particular culture depended upon the culture with which it was paired.

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OBSERVATIONS ON THE MINOR VEGETATION OF THE PINE BARREN SWAMPS IN SOUTHERN NEW JERSEY[1]

S. LITTLE

The purpose of this paper is to record observations on the occurrence of nonarborescent species in some swamps of southern New Jersey and to describe the conditions under which they were found.

Information about these species was collected during a study of the successional trends in stands of whitecedar, *Chamaecyparis thyoides*, and associated hardwoods. The study was made in the New Jersey pine barrens. Both arborescent and nonarborescent members of the plant communities were studied. Only the nonarborescent vegetation is described in this paper. The arborescent species are discussed in another paper (Little 1950).

Of the lichens collected, the Cladoniae were identified by Dr. A. W. Evans of Yale University, all others by Mr. G. G. Nearing of Ridgewood, N. J. Dr. Margaret H. Fulford of the University of Cincinnati identified the liverworts. Dr. L. E. Anderson of Duke University identified all the mosses except members of the genus *Sphagnum*, which were identified by Dr. H. L. Blomquist, also of Duke University. Dr. J. M. Fogg, Jr., of the University of Pennsylvania identified all higher plants—or checked the author's identification of them.

In this paper most of the common names, as well as scientific names except where the authority is given, follow Kelsey and Dayton (1942). However, for the sake of brevity some common names have been shortened: for example, whitecedar falsecypress to whitecedar and trident red maple (*Acer rubrum trilobum*) to red maple.

Description of areas. Stands of whitecedar, swamp hardwoods, and mixtures of whitecedar and hardwoods were included in the study. The size of trees in these stands varied; reproduction, sapling-pole and mature stands were all included. Some of the sites had never been cleared for cultivation; others had once been used as cranberry bogs but were reverting, or had reverted, to forest. The study included whitecedar, hardwood, and mixed stands on both formerly and never cultivated sites. It did not include any mature stands on formerly cultivated sites. The principal hardwood in these areas was red maple. Sweetbay, *Magnolia virginiana*,

[1] This paper is part of a dissertation, "Ecology and silviculture of whitecedar and associated hardwoods in southern New Jersey," submitted in 1947 to Yale University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

and blackgum, *Nyssa sylvatica*, also were common. Gray birch, *Betula populifolia*, holly, *Ilex opaca*, and sassafras, *Sassafras albidum*, were found in some areas. Detailed descriptions of the sites and stands can be found in the unpublished dissertation on file at Yale University (Little 1947).

Methods. Plots were established in 16 stands, 6 in former cranberry bogs and 10 in areas that had never been under cultivation. In each stand, vegetation more than 15 feet tall was studied on a 1/10-acre plot, that between 6.1 and 15 feet tall on an inner 1/40-acre plot, and vegetation less than 6.1 feet tall on ten 1/4-milacre quadrats. These quadrats were scattered systematically over the inner 1/40-acre plot.

The presence of each nonarborescent species was noted in these quadrats and plots. The frequency with which these plants were found is shown in table 1, in two ways. First, the number of plots where each species was found is listed. Second, each species, other than lichens, was given a frequency rating for the plots where it was found. The range of these ratings is shown in the table. The ratings were as follows: 1. observed in area, but found on no more than 2 quadrats; 2. found on 3 to 5 quadrats; 3. found on 6 to 8 quadrats; 4 found on 9 to 10 (all) quadrats.

The general conditions where each plant was found are also shown in table 1. The conditions shown are stand composition, stand size (size of the tree overstory), and history of past use. The abbreviations used in the table to indicate these general conditions are as follows: W—stands predominantly of whitecedar; M—stands of mixed composition (whitecedar, various hardwoods, and in some stands pitch pine, *Pinus rigida*); H—stands predominantly of hardwoods; R—reproduction, i.e., stands in which most of the future dominants are less than 15 feet tall; SP—sapling-pole, i.e., stands in which the overwood is composed of trees that average between 2 and 5 inches d.b.h. (diameter breast high); M—mature, i.e., stands in which the overwood is composed of trees that average more than 5 inches d.b.h.; F—formerly cultivated; N—never cultivated.

Occurrence of minor vegetation. In all, 124 species or varieties of nonarborescent plants were found—even though the area included in the study plots was small. Many of these plants can probably be found under conditions different from those encountered in this study. *Drosera rotundifolia* is an example. Stone (1911) called this *Drosera* the characteristic sundew of the whitecedar swamps. In the areas studied it was found only in whitecedar stands. However, observations in other areas showed that this plant was common for several years in some spots in a pitch pine swamp (a relatively dry, sandy swamp). These spots were where the shrubby turf had been removed for use in stabilizing earthen dams and road banks.

Occurrence of certain vascular plants. Seven shrub species are of primary importance, and were found in nearly all habitats. In order of

TABLE 1. *Minor vegetation found in whitecedar-hardwood swamps of southern New Jersey.* (For explanation of symbols, see text.)

Species	Number of areas where found	Frequency in these areas	Stand composition: and size of stand	Site formerly (F) or never (N) cultivated
SHRUBS				
Alnus rugosa	2	1	W-M: SP-M	N
Amelanchier canadensis	4	1–3	M-H: SP-M	N
Aronia arbutifolia	1	1	M: R	F
Chamaedaphne calyculata	4	3–4	W-M: R-SP	F
Clethra alnifolia	15	1–4	W-M-H: R-SP-M	F & N
Gaylussacia baccata	2	2–3	W-M: R-SP	F
G. dumosa	2	1–2	W-M: R	F & N
G. frondosa	11	1–3	W-M-H: R-SP-M	F & N
Ilex glabra	2	1–2	W-H: R-M	N
I. laevigata	1	1	M: SP	N
Kalmia angustifolia	6	2–4	W-M-H: R-SP	F & N
K. latifolia	4	3–4	M-H: R-SP-M	N
Leiophyllum buxifolium	1	1	M: R	F
Leucothoe racemosa	10	1–3	W-M-H: R-SP-M	F & N
Lindera benzoin	3	1–2	M-H: R-M	N
Lyonia ligustrina	6	1–3	M-H: R-SP-M	F & N
L. mariana	4	2–3	W-M-H: R-SP	F
Myrica pensylvanica	1	3	W: R	N
Quercus ilicifolia	1	1	M: SP	N
Toxicodendron vernix	6	1	W-M-H: R-SP-M	N
Rhododendron viscosum	13	1–4	W-M-H: R-SP-M	F & N
Vaccinium atrococcum	6	1–2	W-M-H: R-SP-M	F & N
V. corymbosum	13	1–3	W-M-H: R-SP-M	F & N
V. pallidum	9	1–3	W-M-H: R-SP-M	F & N
Viburnum nudum	1	1	M: SP	N
VINES AND SUBSHRUBS				
Decodon verticillatus	3	1	W-H: M	N
Dioscorea villosa	2	1	M-H: SP-M	N
Gaultheria procumbens	1	3	W: R	N
Hypericum densiflorum	1	2	M: R	F
Mitchella repens	2	1	W-M: SP-M	N
Parthenocissus quinquefolia	2	1–3	W-M: R-M	N
Rubus hispidus	3	2–4	M: R-SP	F & N
Smilax glauca	4	1–4	W-M-H: R-SP	F
S. rotundifolia	7	1–3	W-M-H: R-SP-M	F & N
Toxicodendron radicans	5	1–3	W-M-H: R-M	N
Vaccinium macrocarpum	6	1–4	W-M-H: R-SP	F & N
HERBS				
Andropogon glomeratus	1	2	M: R	F
Aralia nudicaulis	3	1–3	M-H: R-M	N
Aster nemoralis	1	3	M: R	F
Bartonia paniculata (Michx.) Robinson	3	1–3	W-M: R-SP-M	N
Campanula aparinoides	1	1	W: SP	F
Carex emoryi	1	4	M: R	F
C. folliculata	1	1	M: SP	N
C. howei Mackenzie	2	1–3	W-M: SP-M	N
C. incomperta Bicknell	1	1	M: R	F
C. littoralis Schwein.	3	1–4	W-M-H: R	F

TABLE 1, *continued.*

Species	Number of areas where found	Frequency in these areas	Stand composition: and size of stand	Site formerly (F) or never (N) cultivated
C. stellulata Good. var. *cephalantha* (Bailey) Fernald	1	3	W: SP	F
C. striata Michx. var. *brevis* Bailey	1	1	M: R	F
C. strictior	1	2	M: SP	N
C. subulata Michx.	5	1–2	W-M-H: R-SP-M	N
C. trisperma Dewey	2	1–2	M: SP	N
Drosera longifolia	1	2	M: R	F
D. rotundifolia	3	1–4	W: R-SP-M	F & N
Eleocharis tuberculosa	1	2	M: R	F
Eriophorum virginicum	2	1	M: R	F & N
Juncus canadensis	1	1	M: R	F
Muhlenbergia uniflora	1	1	M: R	F
Orontium aquaticum	2	1	W-H: SP-M	N
Panicum verrucosum	1	2	M: R	F
Peltandra virginica	1	2	W: M	N
Pogonia ophioglossoides	1	2	W: R	N
Polygala brevifolia Nutt.	2	1–2	W-M: R	F & N
Rhexia virginica	1	2	M: R	F
Rynchospora alba (L.) Vahl.	2	1–3	W-M: R	F & N
Sabatia lanceolata (Walt.) T. & G.	1	1	M: R	F
Sarracenia purpurea	2	1–3	W-M: R-SP	N
Solidago tenuifolia	1	1	M: R	F
Trientalis borealis	2	1–2	W: R-M	N
PTERIDOPHYTES				
Aspidium simulatum Davenp.	1	1	W: M	N
Lycopodium inundatum L. var. *adpressum* Chapm.	1	2	M: R	F
Osmunda cinnamomea	8	1–3	W-M-H: R-SP-M	F & N
Schizaea pusilla	1	1	W: R	N
Woodwardia areolata	4	3	M-H: R-SP-M	N
W. virginica	7	2–4	W-M-H: R-SP-M	F & N
LIVERWORTS				
Bazzania trilobata (L.) S. F. Gray	4	1–2	W-H: M	N
Calypogeia trichomanis (L.) Corda	12	1–4	W-M-H: R-SP-M	F & N
Microlepidozia sylvatica (Evans) Joerg.	14	1–4	W-M-H: R-SP-M	F & N
Odontoschisma prostratum (Sw.) Trevis	15	1–4	W-M-H: R-SP-M	F & N
Pallavicinia Lyellii (Hook.) S. F. Gray	9	1–4	W-M-H: R-SP-M	F & N
MOSSES				
Aulacomnium palustre (Web. & Mohr.) Schwaegr.	7	1–4	W-M-H: R-SP-M	N
Dicranum flagellare Hedw.	11	1–4	W-M-H: R-SP-M	F & N

TABLE 1, *continued.*

Species	Number of areas where found	Frequency in these areas	Stand composition: and size of stand	Site formerly (F) or never (N) cultivated
		MOSSES		
D. flagellare var. *minutissimum* Grout	4	1–2	M-H: R-SP-M	N
D. scoparium (L.) Hedw.	7	1–4	W-M-H: R-SP-M	N
Hypnum imponens Hedw.	4	1–2	W-M-H: SP-M	N
Leucobryum glaucum (Hedw.) Schimp.	10	1–4	W-M-H: R-SP-M	F & N
Leucodon julaceus (Hedw.) Sull.	1	1	H: M	N
Plagiothecium micans (Sw.) Paris	7	2–4	W-M-H: R-SP-M	N
Platygyrium repens (Brid.) B. S. G.	1	1	H: M	N
Polytrichum commune Hedw.	1	1	M: R	F
P. ohioense Ren. & Card.	2	1–2	W-M: R	F
Sphagnum compactum DC.	3	2–4	W-M-H: R	F
S. cuspidatum Ehrh.	1	4	H: R	F
S. magellanicum Brid.	12	2–4	W-M-H: R-SP-M	F & N
S. recurvum Beauv.	11	1–4	W-M-H: R-SP-M	F & N
Tetraphis pellucida Hedw.	3	2–3	W-H: R-M	F & N
Thelia hirtella (Hedw.) Sull.	1	1	M: SP	N
Thuidium delicatulum (Hedw.) Mitt.	3	1–2	W-H: SP-M	N
		LICHENS		
Bacidia chlorosticta (Tuck.) Schneid.	1	.....	H: M	N
Cetraria aleurites (Ach.) T. Fries.	2	.....	W-H: R-M	N
C. ciliaris Ach.	2	.....	W-M: SP-M	N
C. juniperina (L.) Ach.	1	.....	W: SP	F
C. lacunosa Ach.	1	.....	W: M	N
C. placorodia (Ach.) Tuck.	1	.....	W: M	N
Cladonia bacillaris (Ach.) Nyl.	5	.....	W-M-H: R-SP-M	N
C. calycantha Del.	7	.....	W-M: R-SP	F & N
C. calycantha f. *foliosa* Vainio	2	.....	W-M: R	F & N
C. chlorophaea (Floerke) Spreng.	1	.....	H: M	N
C. coniocraea (Floerke) Spreng.	2	.....	H: M	N
C. coniocraea f. *ceratodes* (Floerke) Dalla Torre & Sarnth.	3	.....	M-H: R-SP	N
C. cristatella Tuck.	4	.....	W-M-H: R-SP	F
C. cristatella f. *vestita* Tuck.	1	.....	M: SP	N
C. didyma (Fée) Vainio	1	.....	M: SP	N
C. didyma f. *squamulosa* Robbins	1	.....	H: M	N

TABLE 1, *continued.*

Species	Number of areas where found	Frequency in these areas	Stand composition: and size of stand	Site formerly (F) or never (N) cultivated
		LICHENS		
C. didyma f. *subulata* Sandst.	1	.....	H: M	N
C. incrassata Floerke	5	.....	W-M: R-M	N
C. incrassata f. *squamulosa* (Robbins) Evans	2	.....	M-H: R-M	N
C. pleurota (Floerke) Schaer.	1	.....	W: R	F
C. santensis Tuck.	5	.....	W-M: R-SP-M	F & N
C. squamosa (Scop.) Hoffm.	4	.....	W-M-H: R-SP-M	F & N
Parmelia cetrata Ach.	1	.....	H: M	N
P. perforata (Wulf.) Ach.	1	.....	M: SP	N
P. rudecta Ach.	2	.....	M-H: SP	N
P. saxatilis (L.) Ach.	2	.....	M-H: SP	N
P. tiliacea (Hoffm.) Ach.	3	.....	M-H: SP-M	N

frequency, these shrubs were *Clethra alnifolia, Rhododendron viscosum, Gaylussacia frondosa, Vaccinium corymbosum, Leucothoe racemosa, Vaccinium pallidum,* and *V. atrococcum.*

Smilax rotundifolia seems to be more characteristic of mixed or hardwood stands than of whitecedar stands. In this study it was common only in two hardwood stands. Observations in other swamps of the pine region indicate that it is seldom found in whitecedar stands, but is so thick in some hardwood stands that they are difficult to penetrate.

Density of the overstory and site conditions seemed to control the occurrence of cranberry, *Vaccinium macrocarpum,* in the study areas. Although cranberry was still present in most of the areas where it had been cultivated, it was common only in three reproduction stands on relatively wet sites. It was rare under two stands on relatively dry sites, even though one was still open reproduction; and it was not found on the wet site where a dense sapling-pole stand of whitecedar had developed.

Two ferns, *Woodwardia virginica* and *Osmunda cinnamomea,* were found in nearly all habitats, and the occurrence of only one fern, *Schizaea pusilla,* seemed to be associated with a specific habitat. *Schizaea* was found only in the heart of one whitecedar swamp, although Stone (1911) described the favorite habitat of this fern as a moist, sandy spot on the edge of a whitecedar swamp. This plant was sparse in the study plot, but very common in the adjoining area. There it grew on old stumps, logs, and small hummocks, between which there were hollows 2 to 5 feet wide filled with standing water. Usually there was little or no tree growth on the hummocks where

Schizaea grew, and usually, too, there was little or no peat covering the logs or stumps. Apparently this habitat was not an unusual place to find *Schizaea*, because it is known to grow in two other areas that provide similar open and wet habitats.

Occurrence of liverworts and mosses. Liverworts were most characteristic of mature whitecedar stands on relatively wet sites. They were commonly found in the hardwood swamps, but in smaller, less noticeable patches than under the mature stands of whitecedar.

The growth of *Sphagnum* was apparently related more to moisture and light conditions than to either type of stand or land-use history of the areas. The best growth of *Sphagnum* was on very wet sites where there were large hollows over which tree crowns had not wholly closed. This was the condition in parts of a sapling-pole hardwood stand and of a reproduction stand of whitecedar, both in areas never cultivated. There the beds of *Sphagnum* were dense and unbroken for several feet. Good development of *Sphagnum* was observed in two mature whitecedar stands, in a mixed sapling-pole stand, and in certain parts of the abandoned cranberry bogs that were relatively wet and open. The poorest growth of *Sphagnum* was in areas where the litter was thick, the shade heavy, or the site relatively dry.

The other mosses were less common and formed smaller beds than *Sphagnum*. They were found in small patches in various areas, more commonly under mature hardwood stands than elsewhere.

Occurrence of lichens. The number of lichen species per plot was greatest in the hardwood and mixed stands on areas that had never been cultivated, but the most striking growth of lichens was in the sapling-pole or mature stands of whitecedar. There certain lichens, such as *Cladonia incrassata* Floerke, covered much of the bark on the lower boles of the trees. However, only 2 to 3 species were found in these stands, compared to 4 to 8 species in the mixed or hardwood stands.

Successional stages. There are very few stages in the secondary succession of dominant vegetation. The principal arborescent invaders of open areas are whitecedar, red maple, gray birch, and pitch pine. Both the birch and pine are less tolerant of shade than whitecedar. However, whitecedar stands are subclimax to a hardwood association dominated by red maple, blackgum, and sweetbay (Little 1950).

The composition of minor vegetation on these sites is greatly affected by the stage in succession of the dominants, as well as by site moisture and stand density. Recently abandoned cranberry bogs contain few or no lichens, probably because the trees are small and there are no stumps nor logs, but these areas do have much more herbaceous vegetation than the forest stands. Whitecedar stands may have some herbs not found in the hardwood swamps of this study—e.g., *Pogonia ophioglossoides, Sarracenia purpurea, Drosera*

rotundifolia, Trientalis borealis, and *Bartonia paniculata* (Michx.) Robinson. Shrubs are scattered, forming an inconspicuous layer, under dense, pure stands of whitecedar. However, if these stands are partially cut, the shrubby layer increases greatly in density (Moore and Waldron 1938, Little 1950). Shrubs tend to form the densest, most conspicuous layers under the climax hardwood stands.

SUMMARY

1. The vegetation was studied by quadrat samples on 16 areas in the swamps of the New Jersey pine region. These areas included both formerly cultivated sites and sites that had never been cultivated. Both had stands principally of whitecedar, swamp hardwoods, or a mixture of these trees. This paper presents an annotated list of the minor vegetation found in these areas.

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FOREST SERVICE, U. S. DEPARTMENT OF AGRICULTURE

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BULLETIN OF THE TORREY BOTANICAL CLUB
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CYTOGEOGRAPHY OF CLAPPERTONIA IN WEST AFRICA[1]

J. T. BALDWIN, JR. AND BERNICE M. SPEESE

Clappertonia Meisn. (*Honckenya* Willd.) is a genus of two species of Tiliaceae. *C. ficifolia* Decne. is found throughout tropical Africa; *C. minor* Becherer, from Sierra Leone to the Gold Coast (Hutchinson and Dalziel, 1927).

The two representatives of *Clappertonia* differ in habit and ecological requirements. *C. minor* is, except for habit of growth, a miniature morphological edition of *C. ficifolia*. The latter is a coarse shrub to a height of six feet in open marshy or wet situations, which may or may not become desiccated during the dry season. Thousands of such situations are, for example, throughout the small country (*ca.* 37,000 square miles) of Liberia. Populations are often great. *C. minor* is a weak-stemmed shrub prostrate to two or three feet in exposed dry places. It, too, is common in Liberia. Both species have rough foliage and lavender—rarely white—flowers and prickly capsular fruits filled with many seeds.

The large—to three inches when opened out—flowers of *ficifolia* make this one of the most attractive shrubs in West Africa. But, though the plants flower continuously over long periods, the individual flowers are ephemeral.

Some attention is being currently accorded *ficifolia* as a possible commercial source of fiber (Kew Bulletin, No. 1, 1950). In parts of the range of this plant the native peoples have for centuries obtained from it a fiber comparable to jute (Dalziel, 1948). It is "distinctly superior to the latter in many respects, and more particularly in strength" (Dodge, 1897). The plant grows rapidly. Even under greenhouse conditions in Virginia, *ficifolia* comes rather quickly into flower and thrives. Both species are readily propagated from seed and from cuttings.

C. ficifolia and *C. minor* both have a $2n$-number of 36 chromosomes (figs. 1–2). The chromosomes are small, and the complements of the two species similar. Apparently, from gross morphological characters and from cytological data, the two plants are closely related. But no evidence of natural hybridization was found. Different ecological demands keep the plants isolated. The more restricted geographic occurrence of *minor* suggests derivation from *ficifolia*.

The two species should be hybridized. The resultant plant might show

[1] The collections on which this report are based were made by the senior author as Horticulturist (1947–1948), Economic Mission to Liberia, U. S. Department of State, and as Principal Botanist (1949–1950), Division of Plant Exploration and Introduction, U. S. Department of Agriculture.

heterosis. The hybrid could be established as a clone. Such a plant might prefer a habitat intermediate between the wet one of *ficifolia* and the dry one of *minor;* this would likely be of considerable agricultural advantage.

Chromosome determinations were made from leaf smears. The $2n$-number of 36 was found for *C. ficifolia* from Ganta, Sanokwele District and from Roberts Field, Montserrado Co., Liberia, from Douala and from Nola, French Cameroons, and from Leopoldville, Belgian Congo. And for *C. minor:* from Vonjama, Vonjama District, and from Boporo, Boporo District, Liberia.

Specimens of *Clappertonia* from Liberia have been deposited in herbaria of the institutions as indicated below:

1

2

FIGS. 1–2. Chromosomes of *Clappertonia* from leaf smears. FIG. 1. *C. ficifolia*, $2n = 36$. FIG. 2. *C. minor*, $2n = 36$. × 2200.

C. ficifolia Baldwin 5852 Montserrado Co.: near Monrovia. In marsh. June 3, 1947. S(mithsonian Institution) and M(issouri Botanical Garden).
———— *14443* Montserrado Co.: Roberts Field. Relatively dry situation. July 25, 1947 (seed). K(ew) and U. S. N(ational) A(rboretum).
———— *14444* Sanokwele District: Ganta. In marsh. September 16, 1947 (seed). S.
C. minor 9238 Sanokwele District: Ganta. On dry bank. September 15, 1947. S, M, USNA.
———— *9414* Sanokwele District: Gbau. On rock outcrop. Frequent throughout area. September 22, 1947. S.
———— *9871* Vonjama District: Vonjama. October 22, 1947. S, M, USNA.
———— *10507* Montserrado Co.: Monrovia. December 3, 1947. S, M.
———— *11296* Grand Bassa Co.: across river from River Cess. March 9, 1948. S, M, USNA, K.

SUMMARY

1. *Clappertonia* is an African genus of Tiliaceae with two closely related species differing greatly in habit of growth and ecological requirements.

2. *C. ficifolia* was found at five widely separated stations to have a $2n$-number of 36 chromosomes: *C. minor*, at two stations to have the same number. Chromosomes are small. Determinations were from leaf smears.

3. *C. ficifolia* holds some promise as a commercial source of a jute-like fiber. The plant grows rapidly either from seed or from cuttings. It prefers a wet habitat.

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TORREYA

Bryophytes of the Beaver Lake Region of New Jersey—A New Station for Pohlia carnea (L.) Lindb. Following Mr. Nearing's Torrey field trip to Andover, N. J. on April 23, 1950, a stop was made about a quarter of a mile west of Beaver Lake on highway 23, to observe a stand of *Blasia pusilla* which he had discovered growing on a bank by the side of the road. The large number of mosses and liverworts noted, the abundance of some of the species, and collections of some unusual things prompted a return visit to the region in October of the same year. A total of seventy-seven Bryophytes including nineteen liverworts was found and identified, the majority being within a relatively small area.

In the spring *Pohlia carnea* (L.) Lindb., a moss found only a few times in eastern United States was discovered on the wet sandy clay of the bank by the roadside. A fine specimen with ripe capsules was collected and the identification has been confirmed by Dr. H. S. Conard. It was not found later in the season, but without the capsules it could be overlooked very easily. The more common *Pohlia Wahlenbergii* was also present, but in the sterile condition.

The *Blasia* was abundant in the spring and bore numerous capsules filled with spores which must have germinated freely, for in the fall the number of plants had been multiplied many times over, not only by the spores but also by the gemmae found in the flask-shaped receptacles. One area on the moist bank fully twenty-five feet square was especially outstanding, since the ground was almost entirely covered by this little thalloid liverwort, with a few relatively small patches of mosses intermingled, such as *Pogonatum*, *Ditrichum* and *Dicranella*. Another large area was inhabited by *Blasia* and *Anthoceros laevis*, the latter so plentiful that the capsules gave the appearance of a crop of short grass.

The genus *Dicranella* was represented not only by the common *heteromalla*, but also by the less frequent species, *varia* and *rufescens*, both growing in the profusion which seems to be the rule here. The pretty capsules gave a reddish tinge to great patches of otherwise bare soil. Other rather extensive areas appeared reddish brown even at a distance, due to a cover of the tiny leafy liverwort, *Plectocolea crenulata* which was fruiting freely.

On the north side of the road there was a woods and a rocky stream, an entirely different habitat with a different moss flora. In the stream *Fontinalis Novae-Angliae* and *Eurhynchium rusciforme*, both bearing capsules, were on and among the rocks. Four species of *Brachythecium* all with capsules and the sterile *Brachythecium rivulare* were noted. On the rocks in the drier parts of the woods, two *Grimmias* and *Rhacomitrium* were collected.

Although Bryophytes received the most attention, other interesting plants were not lacking, and nineteen species of Pteridophytes were found. In October two species of gentian were in flower, *G. crinita* and *G. quinquefolia*.—ELVA LAWTON, Hunter College.

Oakes Ames, Sept. 26, 1874–April 28, 1950, was an outstanding teacher and research worker in the field of economic botany but no doubt he was better, and certainly more widely, known for his studies and publications dealing with the Orchidaceae. These began with a collection of living specimens made during his youth. They continued throughout his lifetime and brought him recognition as the world's leading authority in the field.

A graduate of Harvard, 1898 and A. M. 1899, he served the institution as Director of the Harvard Botanical Garden, Professor of Botany and Chairman of the Division of Biology, Arnold Professor of Botany, Director of the Botanical Museum, and, in the later years, as Associate Director and Research Professor of Botany, Emeritus.

His publications indicate the breadth of his interests. Orchidology was approached

from many angles and these studies brought him the gold medal of the American Orchid Society in 1924. Other honors were his and an honorary Doctor of Science was conferred upon him by Washington University in St. Louis. His membership in and recognition by learned societies was equally broad. But he contrived to build his greatest prize, the Ames Orchid Herbarium of 65,000 sheets of plants and reproductions of valuable material from European herbaria, together with an extraordinary library. All this is now in the Botanical Museum at Cambridge. He likewise assembled a large herbarium and an extensive library of economic botany in connection with his teaching duties in this field.

Ames is described as a quiet, shy man with a remarkable memory and a strong sense for justice. His works give testimony to an unyielding devotion to the achievement of any task undertaken. There was a community of interest with his wife, who survives him, and it was she who prepared the drawings which do so much to enhance his publications. There are four surviving children.

A more detailed biography by Charles Schweinfurth, with titles of important publications, has appeared in American Orchid Society Bulletin 19: 299–301. 1950. The author has permitted this abstract.—J. A. S.

Book Reviews

Gray's Manual of Botany. Eighth (centennial) edition-illustrated. A handbook of the flowering plants and ferns of the central and northeastern United States and adjacent Canada. Largely rewritten and expanded by Merritt Lyndon Fernald . . . with assistance of specialists in some groups. lxiv, 1632 p. 1806 (i.e. 1818) fig. (incl. 13 fig. on "pl." 1–3). 23.5 cm. American Book Company, New York [etc.]. 1950. $9.50.

Few botanical works published in recent years have been so eagerly awaited as the eighth edition of Gray's Manual of Botany. The seventh edition, issued in 1908, had long been out of date. The uncertain condition of Professor Fernald's health, and in particular the impaired state of his vision, were well known, and there was widespread apprehension that he might be unable to complete the revision, in large part the rewriting, of the work for which he was so supremely fitted by more than half a century of intensive collecting and study. Fortunately these fears were not realized. With the capable assistance of Dr. Bernice G. Schubert, who has cooperated with him in much of his recent taxonomic work, the book was seen safely through the press and finally issued in early July, 1950, about two months before Professor Fernald's sudden death from a heart attack on 22 September. He had, in fact, already found opportunity to accumulate a considerable body of additions and corrections, which have been entered in a copy of the work at the Gray Herbarium.

This eighth edition is based on a vastly wider field acquaintance with the plants occurring in its range and a very much more intensive study of herbarium material than any of its predecessors. The pages of every one of the 52 volumes of Rhodora bear witness to the reviser's activity in both these branches of botany. Outstanding in respect to the number of species brought into the Manual range is his work in Quebec in 1902 and later with J. Franklin Collins and others, in Newfoundland on trips with Wiegand, Griscom, Bayard Long, Fogg, and others between 1910 and 1929, and in Virginia with Griscom, Long, and others, during the last active collecting years of his life, from 1933 to 1946. It is probably safe to say that this edition of the Manual is based on more years of active field work and intensive and productive taxonomic study on the author's part than any other flora of any comparable area of the world.

The eighth edition, like the seventh, is a keyed descriptive account of the vascular plants of the northeastern and north central states and adjacent Canada; earlier editions had stopped at the northern boundary of the United States. The range has now been extended northward to take in Newfoundland, Anticosti, and westward along the 49th parallel in Quebec and Ontario to the northwestern corner of Minnesota. The western and southern boundaries are unchanged, reaching from the western boundary of Minne-

sota and Iowa south along the 96th meridian to the southern edge of Kansas, thence eastward along the southern boundaries of Missouri, Kentucky, and Virginia to the sea. As is pointed out in the preface, the greater part of the increase in species has come about not so much through the inclusion of Newfoundland and other northern regions as through the discovery by the reviser and his coworkers in Virginia of hundreds of species previously unknown north of the Carolinas or even more southern states.

The seventh edition contained 926 pages, the eighth has 1696; but the size of the type page is over 40% greater, so that the total amount of printed matter is two and one-half times that of the previous edition. Nevertheless the printed volume itself is only 2.5 cm. higher, not quite 2 cm. wider, and 1.6 cm. thicker, but its pages are still too high and wide to make possible the issue of a field edition that could be carried comfortably in the pocket. The increase in size is due partly to the greater number of entities included (a total of 8340 species and infraspecific forms and hybrids, as opposed to 4885 in the seventh edition—an increase of 70%), partly to the generally fuller descriptions of species, partly to the ampler keys to species, and partly to the insertion of full-size keys to varieties whenever there are three or more of them within a species (except in *Crataegus*). If the work is to retain the preeminent position it has held for so many years as a field manual as well as a reference work, it is essential that an abridged edition be made available, with somewhat simplified keys, less lengthy specific descriptions, omission of explanation of scientific names, and the treatment of varieties, forms and hybrids either omitted entirely (but with references to the proper pages in the Manual) or reduced to a minimum.

The number of figures has gone up from 1036 to 1818, but their usefulness as a complement to the descriptions has scarcely increased in the same proportion. In too many cases both the new figures and those carried over from the seventh edition have been so much reduced in reproduction that the distinctive characters have been lost, as for instance in the seeds of *Cerastium* and some of the acorn cups; compare also the seeds of *Montia* on p. 609 with the original figures in Rhodora for 1910, and the illustrations of *Amelanchier* with those in the same journal for 1912. Sometimes the drawings fail to bring out anything distinctive, like those of four alleged species of *Urtica* on p. 557, suggesting that Hermann's combination of the first three into a single variety of the fourth may be nearer the reality; or like the figures of four species of *Vernonia* on p. 1360), of which three show no appreciable differences of any sort, while the fourth (fig. 146) scarcely bears out the distinctive characters mentioned in the description. The bits of stem and inflorescence shown in the drawings of *Panicum* are in many cases too fragmentary to contribute anything to the identification of the species figured. But many of the new drawings are quite worthy of a place with those carried over from the seventh edition.

Comparison of the detailed statistics given in the introductory matter of the seventh and eighth editions is of some interest. The number of families has increased from 157 to 168, due in all cases but three to the recognition of segregate families (Zosteraceae, Moraceae, Hippocastanaceae, Hydrocaryaceae, Clethraceae, Pyrolaceae, etc.); the three exceptions are all represented by single species of introduced plants (*Butomus, Melia, Tamarix*), none of which is actually a newcomer to the region since 1908. A few families have been suppressed (Illecebraceae, Fumariaceae, Lobeliaceae), and one (Mayacaceae) has been excluded as not found in our area. The number of genera has gone from 1001 to 1133; of the net increase of 132, introduced genera account for 104, leaving only 28 native genera (net) added, and most of these are old or modern segregates rather than actual new discoveries in the region. Species have increased from 4079 (3413 native, 666 introduced) to 5523 (4425 native, 1098 introduced), or by 35%; native species have increased by practically 30%, introduced species by 65%—the sort of situation that must exist, alas, in practically every country of the civilized world. Much the greatest increase is found in varieties, forms, and named hybrids, which have jumped from 806 to 2817, an increase of practically 250%.

Although the new manual agrees in general features with the previous editions, there are numerous modifications in detail. A synopsis of the orders, families, and higher groups is given in the introduction, in addition to the artificial key to families; the latter

now occupies 22 pages, against 14 in the previous edition, and the diagnostic characters given in the key are usually multiple rather than single. The keys throughout the book might have been better spaced; the runover is indented two spaces in each case, and the subordinate lead following it begins directly under the first letter of the line above (unless it is preceded by a guide-letter), so that it does not stand out well. The key to families includes, under both the monocots and the dicots, a section intended to provide for vegetatively reproducing species or specimens in which the flowers are replaced by bulblets, winter buds, etc.—rather a novel feature in a key, and not too completely worked out here; for instance, there are species of *Juncus* often occurring in this condition which could not be run down by the key on p. xxxiv, which leads only to *J. pelocarpus* and its closest relatives.

The keys to species, which have been made consistently dichotomous, are much fuller than in the previous edition, in many cases becoming practically synopses, and a new feature is the presence intercalated in the text of separate keys to the varieties and forms of a species when these number three or more (except in *Crataegus*). The synoptical type of key running through the text, so commonly used in the previous edition, has disappeared, although traces of it persist in *Viola*. Frequently the keys to the species and infraspecific forms in a given genus take up as much or nearly as much space as the descriptions, or even more. Thus, in the genus *Lespedeza*, the keys amount to 32.5 running cm., the descriptions of species and forms to 46.5 cm.; in *Lathyrus*, to 27 vs. 30.5 cm.; in *Salix*, the keys run to 345 cm., the descriptions to 278 cm.; in *Viola*, the keys occupy 10 pages and a fraction, the descriptions 9 and a fraction. A certain amount of duplication is involved, since the characters given in the keys are nearly always repeated in the descriptions (of the species, not of varieties and forms), but this repetition finds its justification in the practical advantage of having all the distinctive characters brought together in the descriptions.

The generic descriptions include in each case a brief indication of the range of the genus as a whole. There is an explanation of each generic name, as in earlier editions, but with the Greek words romanized and with some previously lacking derivations supplied. There is also an explanation of the meaning of each and every specific, varietal, formal, and hybrid epithet, with complete name and dates of the eponym in the case of personal names; if the dates are unknown, the year in which the plant was described is given instead. The preparation of this feature of the Manual, which will be much appreciated by its users, even by those who do not need to be informed that *americanus* means American and *obtusus* obtuse, must have been time-consuming, but there are indications that Fernald got a good deal of quiet enjoyment out of it now and then, particularly in the genus *Rubus:* witness *Rubus emeritus*, "unfit for service;" *R. plus*, "more—but not the last;" *R. satis*, "enough or sufficient, if not satisfactory;" *R. univocus*, "of one voice; apparently meaning that every one agrees;" *R. dissensus*, "disagreeing;" *R. uniformis*, "uniform; a remarkable character in Rubus." The meanings given are almost always correct; but certainly *uncinata* (p. 930) does not mean "bearing tendrils," and *arboreum* (p. 1125) is not "becoming a tree." Acknowledgments are made in footnotes to authors whose work has been extensively or directly drawn upon, with references to the pertinent publications; in only three cases (Juglandaceae, *Crataegus*, and *Desmodium*), has the treatment been contributed directly by other botanists. Ranges are given in considerably more detail than in any previous edition. Instead of reading rather uniformly from northeast to west and south, as in previous editions, they run from north to south, or south to north, or west to east, depending on the broad range of the species concerned. Names of collectors have, quite properly, been entirely omitted; every plant has to be collected at every limit of its range by someone, and to cite one collector and not another is inconsistent, if not invidious.

Although there appears to be no specific statement to that effect, the nomenclature is of course that of the International Rules, with the exception that Fernald, when using manuscript names published by one author for another, cites a single authority only, the original namer, not the publishing author, although the latter is called for by the International Rules; and in this respect the present reviewer heartily agrees with him.

This had been the almost universal practice since the beginning of binomial nomenclature until it was reversed at the 1930 Congress, with the consequent introduction of considerable confusion because familiar binomials now appeared with strange authorities. On the question of capitalization of personal and some other specific epithets, Fernald expresses himself with his usual vigor in favor of the pertinent Recommendation of the International Rules, which at the time he wrote called for capitals; now that the Recommendation has been reversed (at Stockholm in 1950), those of us who believe in decapitalization can comfort ourselves with the thought that, although we may be "hasty and superficial," we are in agreement with the letter of the Rules at last.

As a natural consequence of the critical study of types of the older authors, mostly preserved in European herbaria, the names of many species have been changed in the forty-odd years since the last previous edition of the Manual, and in too many cases it has been found necessary to use old and well-known names in different senses. These changes are inevitable, and not to be prevented or neutralized by legislation; but they are made as readily intelligible as possible by the use of the necessary synonymy. There is no space to list even the most important changes from the usage of the seventh edition, but it may be noted that the author has found grounds for retaining *Quercus rubra*, *Q. prinus*, and *Q. falcata* in the same acceptation as in that edition.

Some examples may be given to show the growth of representative genera in number of species. *Bromus* had 16 species in the seventh edition, now 22; *Muhlenbergia* 8, now 18; *Eleocharis* 26, now 40; *Scirpus* 35, now 38; *Rhynchospora* 15, now 27; *Carex* (formerly, and still, the largest genus) 185, now 267; *Juncus*, 44, now 56; *Salix* 31, now 54; *Betula* 8, now 14; *Polygonum* 32, now 46; *Cerastium* 6, now 13; *Draba* 8, now 20; *Amelanchier* 4, now 19; *Crataegus* 65, now 103 (with some 73 additional specific names representing plants "of very limited occurrence or of suspected hybrid origin"); *Rubus* 38, now 205 (the most expanded genus in the book); *Epilobium* 10, now 20; *Gentiana* 12, now 23; *Galium* 25, now 30; *Eupatorium* 19, now 26; *Liatris* 8, now 18; *Solidago* 56, now 75; *Aster* 59, now 68; *Antennaria* 11, now 32; *Xanthium* 6, now 15; *Taraxacum* 2, now 11. On the other hand, *Potamogeton* has gone from 38 down to 37 species, *Sisyrinchium* from 13 to 9, and *Oenothera* from 20 to 18, while *Panicum* has increased only to 76 from 73 and *Viola* to 51 from 45.

There is no living botanist whose field and herbarium acquaintance with the flora of the area can compare with that possessed by Fernald; in consequence, any individual attempt to comment critically on the details of the work is bound to be incomplete and one-sided. It is not difficult to find points to criticize, but it cannot be denied that the body of the flora is as sound as any one-man work of this size and of such detailed nature is ever likely to be. With the increasing trend to cooperative effort in scientific undertakings, it is not too much to hope that in the not-too-distant future floras of this sort will be the joint work of several authors, or will at least be subjected to review and correction by specialists while still in manuscript form, before their more obvious errors are perpetuated by printing.

In most cases the keys in the new Manual are much fuller and more carefully worked out than those in the previous edition, and the shift to modern dichotomous keys from the old style arranged by typographical signs will be welcomed by beginner and professional alike. In *Viola*, there are now two keys, one based on flowering, the other on fruiting material; in Umbelliferae, there is an artificial as well as a synoptical key; in Cruciferae the old synoptical key, impossible for the beginner to use, has been dropped and there are now two keys, based on flowering and fruiting specimens respectively; in *Salix*, there are four keys, one synoptical, one based on staminate specimens, one on pistillate material, and one on specimens without flowers or fruit but with mature foliage. But the two keys to the genera of Compositae in the seventh edition, one synoptical and one artificial, have now been omitted, and in their stead we have only a key to tribes (continued by separate keys to the genera of each tribe at the proper places in the text), which contains so many errors that in the case of several tribes, at least, it is only by a happy combination of mistakes that one can possibly arrive at the right destination. In the first place, the word "discoid" applies to the head but not to the flowers themselves;

the proper term for the latter is disk flowers. There is no actual distinction between the first "c. Flowers discoid or discoid and ligulate" [which should read, Heads discoid or radiate] and the second "c. Flowers all with equally or subequally cleft corollas with elongate lobes (simulating deeply cleft ligules)." [They don't, and the heads are technically discoid as in the first "c," or sometimes radiatiform.] The distinction in style appendages between the first "d" (Astereae) and the second "d" (including Heliantheae and Helenieae) indicated in the key is non-existent. The "disk-corollas mostly filiform and truncate" indicated for the Inuleae are mostly not disk corollas properly so called, but marginal pistillate corollas; the pappus in no. 29 is not of scales only, but of scales and bristles, nor can it be called capillary in staminate flowers of *Antennaria;* the heads in most of the genera of the tribe are properly described as disciform, not discoid; and the leaves in all the Manual representatives of the tribe are alternate (not merely "mostly alternate"), although they may be crowded at the base. There are no "half-shrubs" in the tribe Cichoriae in the Manual range.

A few minor points of criticism may be mentioned. The placing of the vernacular names in a separate index on the last 18 pages of the book is very unfortunate, and a great waste of time for the user; anyone who knows plants primarily by their vernacular names is not likely to have much to do with a flora of this kind, and for others these final leaves will always interfere with the finding of the scientific index. If they must be separated (and the necessity for so doing is not evident), then they should have been placed in front of the scientific index, not behind it; as it is, a paper clip can be used to hold them together, but it is far from providing a satisfactory solution. I can find no justification in the Rules for adopting the generic names *Xanthoxylum* Gmel. and *Haplopappus* Endl. and giving the earlier *Zanthoxylum* L. and *Aplopappus* Cass. as their respective synonyms. If the latter are to be regarded as distinct names, then it is certainly incorrect to cite, as authorities for the specific and varietal names here employed, botanists who actually used the displaced spellings (as is true of all the names concerned except *X. americanum* Mill.). And the first botanist to use the etymologically correct but nomenclatorially incorrect spelling *Xanthoxylum* was Philip Miller, not Gmelin. The use of the key character "ovary 5-lobed" versus "4-lobed" as one of the distinctive features of *Isanthus* is a pure error, no doubt tracing back to the same statement in the key to the genera of Labiatae in Gray's Synoptical Flora, where it is obviously a typographical error; this assumed peculiarity of the pistil, in a family so uniform as the labiates, should have led to the examination of specimens before it was incorporated into the key. The entry "i" in the key to Heliantheae on page 1466 has no mate, and should be combined with the first "h," which should be enlarged to read "h. Achenes flat or 3–4-angled, rarely 5-angled or subterete, but then comparatively long and slender; pappus none or a crown or cup or of 1–4 (rarely –6) teeth or awns, these sometimes chaffy." In the descriptions of *Galinsoga ciliata* and *G. bicolorata* and of *Helenium autumnale* and *H. virginicum* there is confusion, in giving the length of the pappus of the disk flowers, between the tube proper and the tubular part (that is, the combined tube and throat) of the corollas, here miscalled the tube.

One of the features that distinguish the book from most other United States manuals is the amount of space devoted to entities below the rank of species, that is, varieties, forms, and hybrids,—the author apparently considering the category subspecies to be needed only for European variations. Many users of the volume will regard this as so much wasted space, others will wish that the coverage was even more complete. Under *Trillium grandiflorum,* for example, 8 forms are described, but the remark "with many scores of aberrant forms described (as well as the above)" seems to be something of an exaggeration, since only about 24 named forms of this species and of those of its forms that were treated as species by Farwell are listed in the Gray Herbarium card index. There has been an honest effort to distinguish between varieties, which in the author's usage are subordinate entities that have a somewhat segregated geographic range, and formae, which have no distinct range but are color variations, leaf and pubescence variants, and so on, including some that are obviously mere freaks or ecological responses. Hybrids, in the great majority of cases, are merely mentioned with a statement of their parent-

age; there are far more of them with binomial names in *Viola* (53) and *Quercus* (43) than in any other genera. A few fairly fixed hybrids of definite range, such as *Lysimachia producta*, are given full treatment and are numbered like species. The formae are usually worked into the descriptive text at the appropriate place, while the varieties, if only one or two, are entered separately with their characters and range; if there are three or more varieties (or varieties and forms), a separate key is usually given directly following the description of the species, after which the varieties (and forms) are listed with their ranges.

It is possible to regard most of the numerous formae and many of the varieties here described as of little taxonomic significance and still to feel that it is well worth while to have their descriptions brought together concisely in one place, both as a record of what nature can do and as a source book for geneticists seeking variations of one sort or another for study.

It remains to add that the book is well printed on thin but fairly firm paper, and that the binding appears capable of withstanding considerable wear and tear. The oak leaf on the cover is that of *Quercus shumardii* (fig. 922 of the text).

All in all, this new edition of the Manual is not only one of the outstanding contributions to North American floristic botany but a worthy memorial to one of the greatest of American systematic botanists. It will remain the standard critical flora of the region for many years to come.—S. F. BLAKE, Division of Plant Exploration and Introduction, Bureau of Plant Industry, Soils and Agricultural Engineering, Beltsville, Maryland.

Variation and Evolution in Plants. By G. Ledyard Stebbins, Jr. 643 pp. illustrated, with bibliography and index. New York: Columbia University Press. 1950.

For some thirty years concepts and methods derived from Cytology and Genetics have been invading the field of Systematics. It would be interesting and instructive to catalogue the various ways in which taxonomists reacted to these migrants. A few were hostile: . . . "Young man, if you want to discuss taxonomy with me you will have to use taxonomic language; when you start saying 'polyploidy' I don't know what you are talking about." On the whole, however, systematists were gracious; their commonest reaction was to comfort themselves with the notion that facts about chromosome numbers and morphology were after all just an extension of their own tried-and-true method of comparative morphology. The assembling of data about chromosomes was therefore to be encouraged; such data would be weighed-in along with the other evidence, meaning no more and no less than facts about sepal shape or leaf pubescence or the form of the achene.

The contrary view that, in discussions of evolution, data about the germplasm itself, are of another order of significance from data about the products of the germplasm, was outside their thinking. Few of them could grasp its implications, even when it was brought to their attention. This may explain why taxonomic monographs, though dealing directly with the consequences of evolutionary processes, have remained utilitarian and with pitifully few exceptions singularly devoid of any fresh information about evolutionary processes.

Stebbins' new book is a brilliant demonstration of what may be done by one who understands how to integrate facts about the germplasm and facts about the products of the germplasm. It demonstrates not only the orderly variation in the end products of evolution; it digs deeper and shows orderly variations in the evolutionary courses leading to those end products. It accompanies careful expositions of the way in which evolution is proceeding in various genera and families with a penetrating discussion as to why the course of evolution is so different in these and other groups. From start to finish the viewpoint is dynamic. The discussion, however, is centered on the evidence. No matter how acceptable a theory, Stebbins does not rest until the critical evidence for and against it has been brought together and given a thorough-going discussion. Natural selection, for instance, is such a reasonable idea that most texts (and much research)

rest their case with the theory. Stebbins instead brings together all the beautiful observational and experimental work on *Camelina*. He makes a creative synthesis of Zinger's classical studies, Sinskaia's rather ecological survey and Tedin's genetic analysis and gives a ten page exposition of exactly how selection did work in that particular instance.

Technically trained both as a taxonomist and a cytologist, it has been possible for him not only to assemble the critical evidence on evolution from these and allied fields, but to integrate it so skillfully that the result will generally be useful to all kinds of biologists. The book has an unusually complete bibliography of nearly 60 pages and an excellent index. EDGAR ANDERSON, Missouri Botanical Garden.

Principles of Plant Infection. (Gäumann, Ernst.) English Edition by William B. Brierley. 543 pp. Hafner Publishing Company. New York.

This book is a translation of *Pflanzenliche Infectionslehre* published in 1946, by Prof. Ernst Gäumann, Professor and Head of the Department of Special Botany, Swiss Federal Institute of Technology, Zurich. Professor Brierley's effort to make the translation complete and accurate deserves special credit and in reviewing this book, we may start by quoting from his prefatory note to the English Edition. "It is fortunate that from time to time in the march of science a scholar of deep insight and widely ranging mind brings together in one volume the whole scope of a particular field of enquiry and synthesizes it in such a way that divergent viewpoints and masses of data fall into place to create a unified and harmonious picture." We have in plant pathology too few treatments of entire subjects and it is of tremendous importance to our science when an individual thoroughly familiar with a topic takes time from his researches to summarize the work which has been done. This work which is the outgrowth of Professor Gäumann's twenty years of teaching, summarizes the inoculation, incubation, and infection phases of plant diseases.

The subject matter is divided into six topics, each occupying a chapter. Chapter one deals with the ingress of the parasite and its establishment in the host tissues. The paths and duration of ingress as well as the influence of environmental factors on the entrance of pathogens are treated. Chapter two discusses the source and transfer of inoculum and the epiphytology of infectious diseases. In Chapter three, entitled "The Parasitic Adaptations of Pathogens," specialization, virulence, and variation in pathogens are discussed. In Chapter four, "The Disease Proneness of the Host," susceptibility and resistance are treated from the standpoint of the morphological and physiological characteristics of the host. The influence of environmental factors on the resistance of the host is also considered. Chapter five treats the morphological and physiological responses of the host. Chapter six, with only five pages, deals with control, a topic more or less outside the author's subject matter. However, Professor Gäumann's brief outline of types of control measures adds value to the book.

This is a valuable text and reference book for advanced students and should be read by all who are interested in the more theoretical phases of plant pathology. The terminology is definitely not American and the reader must keep this in mind. Since the meaning of various terms is often different from our own, topics expected to be found under a certain heading may be found elsewhere. However, subject matter, for the most part, is presented in a logical sequence. Professor Gäumann frequently compares and contrasts plant and human diseases. This is both interesting and helpful.

This book contains over 300 figures which are used to illustrate the principles discussed. Since Professor Gäumann often uses pathogen and host names which are unfamiliar to English and American plant pathologists, Professor Brierley has included an appendix giving the names commonly adopted by workers in the United Kingdom and United States.—B. H. DAVIS, Rutgers University, New Brunswick, New Jersey.

FIELD TRIP REPORTS

June 18, 1950. Van Cortlandt Park, Bronx, N. Y. A group of fifteen enjoyed a walk along a trail that J. Otis Swift had walked for many years. We stopped at the Memorial

where a red oak tree is thriving; then we walked along Swampside Trail which has changed because of the construction of a golf course, to the Rocks of Eternal Peace where we rested and talked. We studied plants, trees and bird life and greatly appreciated having Mr. James Murphy as a member of the group as he kindly shared his knowledge with us. Attendance 15. Leader, Jane Meyer.

August 19–20. Bennett's Bog, Cape May County, N. J. This year our trip was chosen at the right time for the height of the bloom of the snowy orchis (*Habenaria nivea*). There were several hundred blooms, a truly thrilling sight, especially for those visitors who had never before located it. *Sclerolepis* was also more abundant this year than last. It was a bit too early to hope to find the pine barren gentian in bloom though towards the end of the period for *Habenaria nivea* one can usually find the first blossoms of the gentian among the grasses of the bog. The visit to the egret roost was very rewarding. At least nine Louisiana herons were observed as well as two yellow crowned night herons. Many snowy egrets, American egrets, and hundreds of little blue heron. Attendance 18. Leader, David Fables.

September 2–4. Malaga Lake, N. J. The group was "housed and fed" at the Hands' and Phillips' bungalow on Malaga Lake. In addition to botanizing at the lake, trips were made to Elmer, South Vineland, Parvin State Park, Bayside, and Sea Breeze—the latter two on Delaware Bay. Some interesting or less common plants seen include: *Dryopteris simulata* (a large stand), *Lycopodium carolinianum, Gymnopogon ambiguus, Setaria Faberii, Smilax laurifolia, Populus heterophylla,* × *Quercus Saulii* (=*Q. alba* × *Q. prinus*), *Phoradendron flavescens, Itea virginica, Desmodium strictum, Stylosanthes biflora, Crotonopsis linearis, Rhus quercifolia, nemopanthus mucronata, Lythrum lineare, Lilaeopsis lineata, Nymphoides peltatum, Aster concolor, Coreopsis rosea, Eupatorium serotinum, E. resinosum, Heterotheca subaxillaris,* and *Prenanthes serpentaria.* Attendance 23. Leaders, Mr. and Mrs. Louis E. Hand.

September 24. New Brunswick, N. J. The canoe trip was held as scheduled and enjoyed by those participating from Watchung Nature Club as well as our own members. Autumn color was beginning to appear in the sumachs, several species of smartweed and tearthumb were in flower; many fruits were observed but the foxgrape attracted most prolonged attention. Attendance 11. Leader, John A. Small.

October 8. Voorhees State Park, High Bridge, N. J. Most of the time was spent in the deciduous forest which has characteristics of the oak-hickory community but also some species of the maple-beech association, including yellow birch and elm. A total list of about 200 species was compiled. The party then drove to Hoffmans and down through the Kenneth F. Lockwood Gorge along the South Branch of Raritan River. Lockwood was formerly editor of the column "Out in the Open" and this stretch of publicly-owned land, his favorite fishing water, was dedicated to him on May 14, 1950. Deciduous forest, some very large hemlocks, and a stand of Rhododendron are to be found in the gorge. Attendance 26. Leaders, L. E. Hand and J. A. Small.

October 15. Van Cortlandt Park, Bronx, N. Y. Although it was sloudy and rainy a group of six walked in the east wood of this park following trails that J. Otis Swift enjoyed. We found much to interest us and helped each other with the identification of plant and bird life. As Miss Farida Wiley had shown the leader poison sumac the week before, this was found again. We concluded this walk by proceeding along the Van Cortlandt swamp which is now partly surrounded by green grass rather than trees and wild shrubbery. Before we left for home we visited the J. Otis Swift Memorial. Attendance 6. Leader, Jane Meyer.

October 15. Tuckerton, N. J. The tide was unusually high and the northeast wind was blowing with a cold, fine rain in the air. The creeks were not only full and difficult to cross but the surface of the marsh was flooded. These conditions gave the members of

the group an idea of the marshes under very different circumstances than they usually see them. Vegetational zonation, both of the higher plants and algae, was discussed as well as the successional changes resulting in coastal submergence. Both the inner margin of the marsh which is moving inland and the outermost margin where the waves are eroding the front of the marsh were examined. Dr. Moul explained some of his studies of the algae of the salt pans where he has been measuring the temperature and salinity variations to which they are subjected. Attendance 8. Leaders, E. T. Moul and M. F. Buell.

October 22. Point Pleasant, N. J. We toured the ponds from Point Pleasant to Shark River with some measure of success. It had been a mild fall to that date and we did not see a few species of waterfowl that might have been present following colder weather. We did see a small band of Canada geese on the pond at Point Pleasant as well as many coots and baldpates. Gannets were sighted offshore near the Point Pleasant inlet. Two purple sand pipers were seen near the breakwater though the presence of too many fishermen discouraged their landing at a convenient spot for ornithologists to observe them well. At Wreck Pond we saw many red-backed sandpipers, yellow-legs, killdeer, as well as an excellent view of a clapper rail. We were at this point joined by Mr. Murphy who had arrived on a train after the group left Point Pleasant, and who caught us afoot at Wreck Pond. Redhead ducks as well as ruddy ducks were present at Lake Como, mixed with scoup, ring-necks, blacks and mallards. We failed to see much at Shark River, more Canada geese but few mergansers. The day had been a very beautiful one and we felt quite rewarded for our efforts. Attendance 23. Leader, David Fables.

October 29. Honerstown, N. J., to visit a stand of hemlocks (*Tsuga canadensis*). The site is a short distance down the Lahaway Creek from Hornerstown, Monmouth County. The hemlocks occupy a steep north-facing slope where the stream has meandered making a big arc against the bank. The hemlocks are healthy although they seem to show a more rapid taper than in sites farther north. The community is spreading out from its center on the bank, there being seedlings and saplings in abundance every direction away from the stream. One tree of black ash (*Fraxinus nigra*) was found growing with the hemlocks. Attendance 12. Leader, M. F. Buell.

November 5. East Millstone, N. J. The excursion included fields situated within the vicinity of East Millstone, Somerset County. The fields studied were all on upland sites of the Triassic shale and varied in age, since the time of last cultivation, from one to sixty years. The one-year field still exhibited tall, dead cornstalks, but the soil was largely colonized by evening primroses (*Oenothera parviflora*), ticklegrass (*Agrostis hyemalis*), and sheep sorrel (*Rumex Acetosella*). At the second station, a five-year-old field, broomsedge (*Andropogon spp.*) was noted as were numerous young red cedars (*Juniperus virginiana*), bayberry (*Myrica carolinensis*), poison ivy (*Rhus Toxicodendron*) and dewberry (*Rubus villosus*). The increase of woody species both in number and size was noted in subsequent stops at fields ten, fifteen, forty, and sixty years of age. Mettlar's Woods, an essentially virgin forest, was the last station visited, for an appreciation of the final stage in succession on the Piedmont, the oak-hickory climax. Dr. Buell demonstrated the use of dendrometers in growth studies currently being conducted on white oak, black oak, and sweet pignut hickory. Attendance 23. Leader, Mrs. Giley E. Bard.

November 19. Pocono Mountains, Pennsylvania. The Pocono Mountains are known to thousands as a vacation paradise whether visiting there in the winter or summer. Our objective was a resume of scenic botanical and geological points of interest within the region. First stop was at the famous Delaware Water Gap where the Delaware River has cut a majestic gorge through the resistant Shawangunk conglomerate. Leaving the Gap, we proceeded to the Devonian Coral reef where all members were able to find ample cup corals, crinoids and other fossils. Lunch time found us on Indian Hill, overlooking a cranberry bog. After lunch, those with boots botanized the sphagnum bog where they

found boreal elements such as black spruce, larch, and bog rosemary as conspicuous representatives. At Buck Hill, the picturesque falls were viewed as well as a primeval forest of hemlock at the bottom of the gorge. The vegetation of the gorge is typical of that found in New England representing the hemlock, white pine, northern hardwoods. Leaving the Falls, we continued up the escarpment of the Pocono Plateau to gain an overall view of the Poconos. In the distance, the Delaware Water Gap could be seen breaking the even line of the Schooley peneplain. Proceeding further north, we entered an extensive beech-maple community dotted with spruce-fir swamps. A final visit in one of these swamps brought the trip to a close. Attendance 43. Leader, William A. Niering.

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INDEX TO AMERICAN BOTANICAL LITERATURE

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TAXONOMY, PHYLOGENY AND FLORISTICS

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